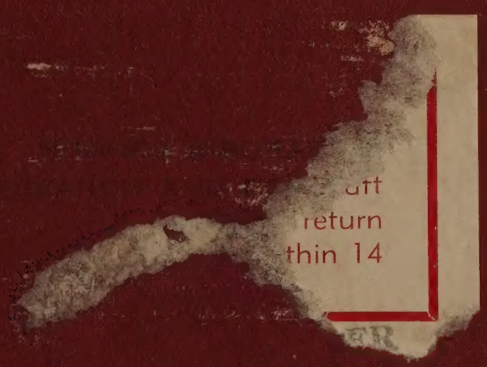
MEASUREMENTS

STANDARD SIGNAL GENERATOR — MODEL 84

Operating INSTRUCTIONS



MEASUREMENTS CORPORATION

BOONTON NEW JERSEY

MEASUREMENTS

STANDARD SIGNAL GENERATOR — MODEL 84

Operating

INSTRUCTIONS

HUGHES AIRCRAFT CO.
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MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

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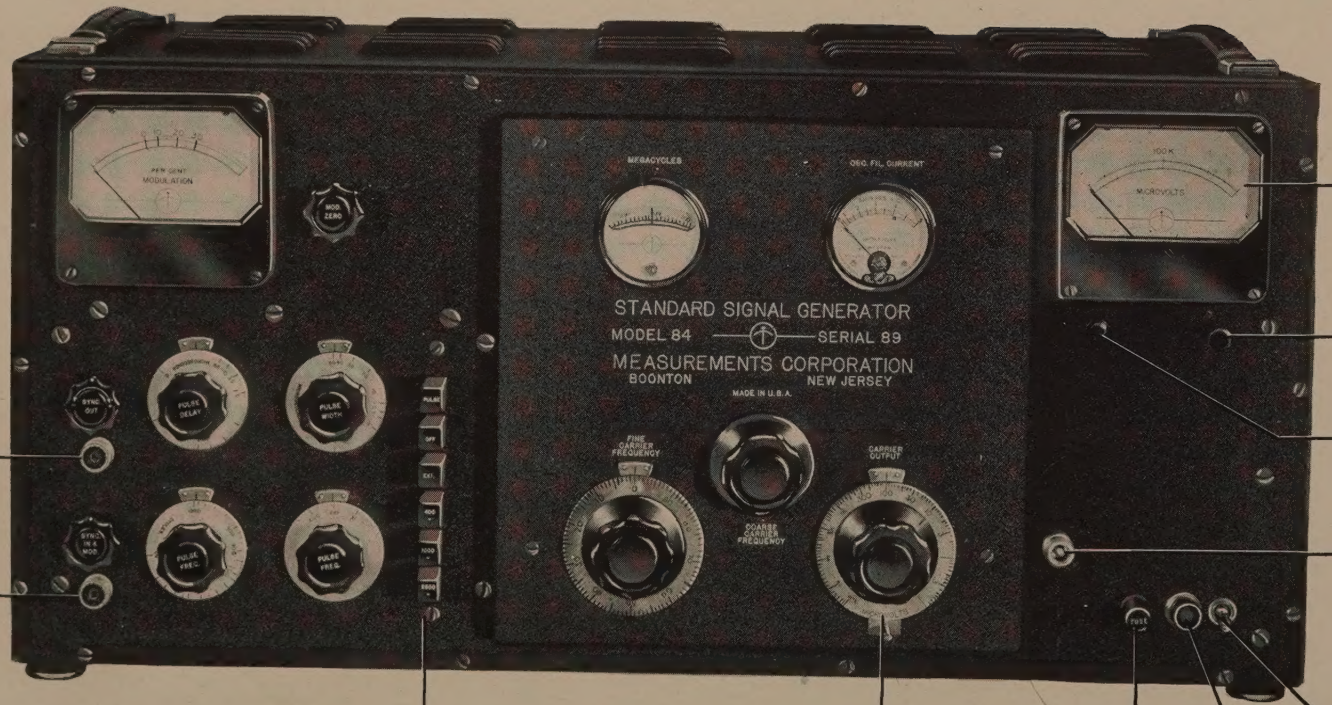
FIGURE 1—STANDARD SIGNAL GENERATOR



SECTION I

GENERAL DESCRIPTION

1. PURPOSE

This handbook is mainly concerned with data necessary for the basic field operation and maintenance of the Model 84 Standard Signal Generator. No attempt is made to discuss the increasing variety of applications of this equipment in ultra-high-frequency engineering.

a. The Model 84 provides a choice of four types of test signal voltage:

(1) A *continuous wave* of UHF carrier (300 to 1,000 mc.), with suitable metering of output and a wide range of attenuation.

(2) A *sine-wave modulated* carrier, using either an internal or external source of modulation, with direct metering of per-cent modulation.

(3) A *pulse modulated* carrier, using an internal pulse generator, with a wide range of repetition frequency, width and delay.

(4) A separate *synchronizing pulse* output for triggering an external time axis in synchronism with the pulsed carrier.

b. A self-contained power supply provides all voltages necessary for operation of the carrier oscillator and modulator tubes. No batteries are required.

2. GENERAL CHARACTERISTICS

a. Carrier Oscillator

(1) The carrier oscillator *range* is from 300 to 1000 megacycles.

(2) The carrier frequency *calibration accuracy* is to within 0.5%.

(3) The *output level* is continuously variable from 0.1 to 100,000 microvolts.

(4) The *output impedance* is fixed at 50 ohms.

(5) *Stray field* is not measurable with the most sensitive receivers.

b. Sine-Wave Modulation

(1) The modulation frequencies produced from an internal source are 400, 1,000 or 2,500 cycles per second (±5%). Provisions are made for external modulation over the range from 50 to 30,000 cycles per second. About 3 rms volts input is required for 30% modulation.

(2) The modulation depth is continuously variable from 0 to 30% as directly indicated on the Modulation Meter.

c. Pulse Modulation

(1) The *repetition frequency* is continuously variable and calibrated from 60 to 100,000 pulses per second, with provisions for synchronizing to an external frequency standard.

(2) The *pulse width* is continuously variable and calibrated from 1 to 50 microseconds.

(3) The *pulse delay* with respect to the synchronizing pulse is continuously variable and calibrated from 0 to 50 microseconds.

d. Synchronizing Pulse

(1) The *repetition frequency* is the same as the modulation pulse.

(2) The *amplitude* is continuously variable in either polarity up to 40 peak volts.

(3) The *width* is fixed at approximately 1.0 microsecond.

e. Power Supply Source

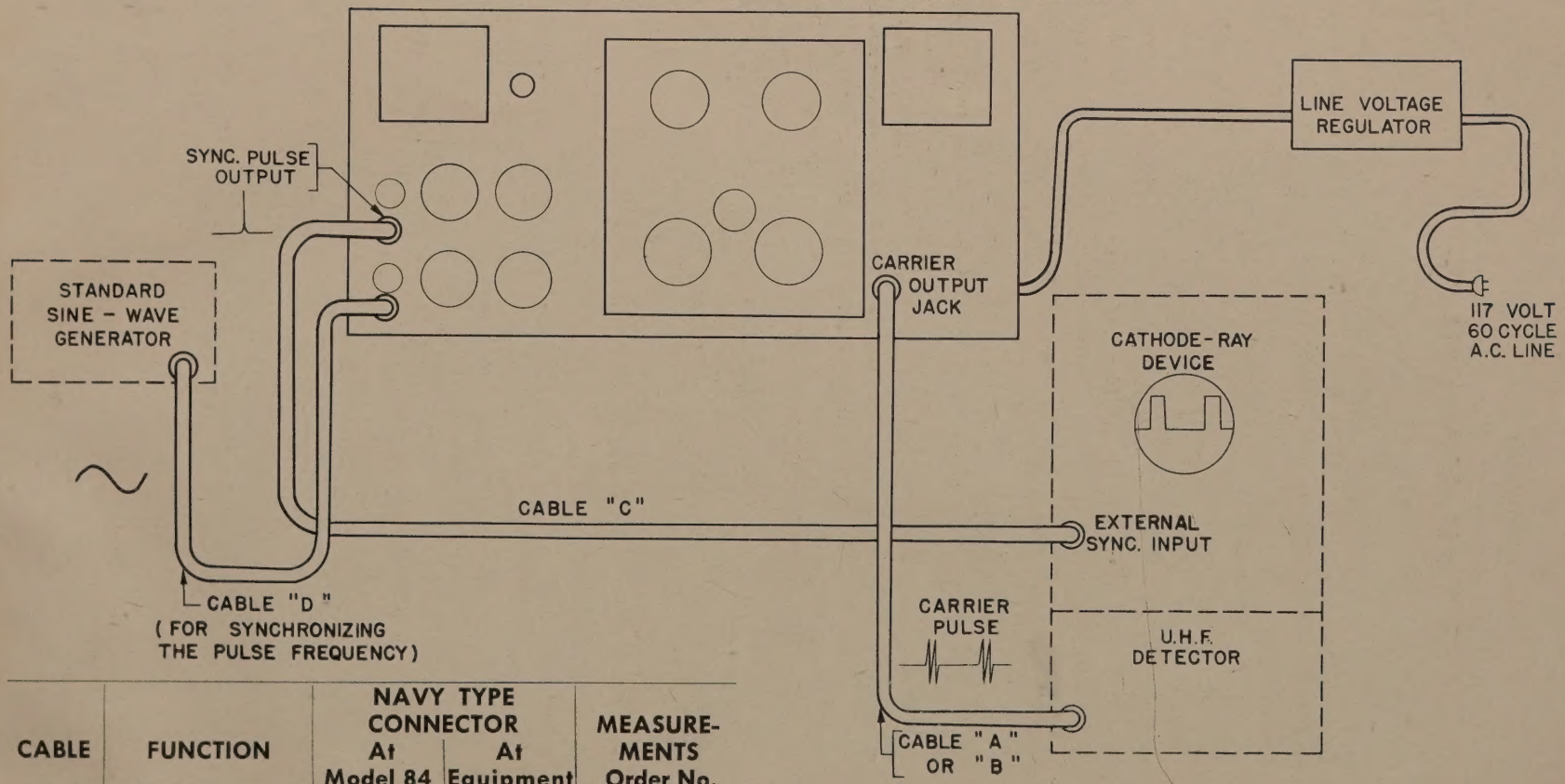
(1) The *supply potential* should be exactly 117 rms volts, to meet the above standards of operation.

(2) The *line voltage regulator* will deliver 117 rms volts regardless of line fluctuations when used with a 60 cycle supply of good frequency stability.

(3) When the line frequency is uncertain, precautions should be taken to assure a constant level of 117 R. M. S. volts.

(4) The *power consumption* with the line voltage regulator is 230 watts. Without the line voltage regulator, the power consumption is 170 watts.

FIGURE 2—CONNECTIONS FOR PULSE MODULATION



CABLE	FUNCTION	NAVY TYPE CONNECTOR At Model 84	NAVY TYPE CONNECTOR At Equipment	MEASUREMENTS Order No.
A	CARRIER OUTPUT (preferred)	No. 49268	No. 49268	84-Z2C-3
B	CARRIER OUTPUT (alternate)	No. 49268	No. 49195	84-Z2C-2
C	SYNC. PULSE or EXT. MOD.	No. 49195	No. 49195	84-Z2C-1
D	SYNC. PULSE or EXT. MOD.	No. 49195	No. 49195	84-Z2C-1

SECTION II

INSTALLATION AND ADJUSTMENT

1. INSTALLATION

Since the Model 84 Standard Signal Generator is test equipment, no permanent installation is required. The equipment should be arranged on a solid bench, *allowing ample room for ventilation* and for making connections such as those in Figure 2. When the Line Voltage Regulator is used, place it as far as possible from all other equipment.

2. PRELIMINARY CHECKS PRIOR TO OPERATION

If it is necessary to know whether the Model 84 is functioning properly, before connecting it to other equipment, the following routine checks can be made:

a. Plug the power cord into the Line Voltage Regulator and connect the Regulator to a 117 volt line having a frequency of exactly 60 cycles.

NOTE: If the line frequency is *not exact*, connect the equipment directly to the 117 volt AC line.

b. Snap up the power switch (located in the lower right hand corner of the front panel). Allow a few minutes for the equipment to warm up.

c. Depress the push-button marked "Off" in the vertical row of six "Modulation Push-Buttons" (see Figure 1).

d. Adjust the Carrier Output Knob until the Carrier Output Meter reads 100K.

e. Adjust the "Mod. Zero" knob until the Per Cent Modulation Meter reads zero.

f. Depress the Modulation Push-Button marked "400" and adjust the "Sync. In & Mod." knob until the Per Cent Modulation Meter reads 30%. This reading should not vary appreciably when the "1000" and "2500" buttons are depressed.

g. Set the right-hand Pulse Frequency dial to X100 and the left-hand Pulse Frequency dial to 100. Set the Pulse Width and Pulse Delay dials to zero and depress the Modulation Push-Button marked "Pulse." While advancing the Pulse Width dial, observe the Carrier Output Meter. If this meter deflects as the Pulse Width is increased, it can be assumed that normal pulsing of the carrier is taking place.

3. EQUIPMENT SUPPLIED

The following equipment is included with each shipment, unless otherwise specified in the order:

Quantity	Description	Designation	Dimensions	Weight
1	Standard Signal Generator	Model 84	Width—26 in. Height—12 in. Depth—10 in.	110 lbs.
1	Coaxial Patch Cable	#84-Z2C-3	Length—48 in.	
1	Coaxial Patch Cable	#84-Z2C-2	Length—48 in.	
2	Coaxial Patch Cables	#84-Z2C-1	Length—48 in.	
1	Line Voltage Regulator	Sola Type 3003	Width—6 in. Height—6 in. Depth—10½ in.	25¾ lbs.
1	Handbook of Operation and Maintenance			

4. EQUIPMENT NOT SUPPLIED

The Model 84 may be used without additional equipment. For certain measurements, however, the following devices may be required:

a. A ***Sine-Wave Oscillator,*** covering the range of 50 to 100,000 cycles, with accurate calibration and a stable output of at least 4 rms volts. This is used as a synchronizing source for certain types of pulse measurement work.

b. A ***Cathode-Ray Oscillograph*** having "video" range amplifiers with satisfactory square wave response at 100 kc., and a deflection sensitivity of at least .01 rms volts per inch over the range of 20 cycles to 2 megacycles.

c. A ***Crystal Modulation Detector*** with 50 ohms input impedance (see Figure 13) may be used for adjusting the Model 84 output when UHF receiving equipment is not available.

5. PHYSICAL DESCRIPTION

The general appearance of the Model 84 front panel (on which all controls are mounted) is shown in Figure 1. The interior views of Figures 3, 4, 5, 6, 7, 8 and 9 show the arrangement of parts. Dimensions and weight of the complete equipment are as listed above.

All assemblies are mounted on the front panel, the case being merely a five-sided steel box into which the complete assembly is inserted and securd by fourteen screws along the outer edges of the front panel.

Since this instrument was designed for laboratory use it should not be subjected to rough handling nor exposed to the weather, except when properly packed in its special shipping container. (See "Packing for Return Shipment," page 21).

6. TUBE COMPLEMENT

Twenty tubes are employed as follows:

Schematic Symbol	*JAN Type Designation*	*Function (See also Wiring Schematic, Figure 15)*
V-1	6V6-GT	Sine-Wave Oscillator
V-2	6H6	% Modulation Metering Diode
V-3	VR-105-30	Regulator for B— supply to V-13
V-4	6V6-GT	Sine-Wave Modulation Output
V-5	6SJ7	Sine-Wave Oscillator
V-6	VR-150-30	Regulator for B+ supply to V-9 and V-10
V-7	6SN7-GT	Fixed Trigger for Sync. Pulse Circuit
V-8	6J5	Sine-Wave and Sync. Input Amplifier
V-9	6SN7-GT	Multi-Vibrator
V-10	6SN7-GT	Negative Trigger
V-11	6AG7	Sync. Pulse Limiter
V-12	6L6	Pulse Modulation Output
V-13	6AG7	Pulse Modulation Limiter
V-14	6SN7-GT	Variable Delay Trigger
V-15	6J5	Sync. Pulse Polarity
V-16	5Y3-GT	Full-Wave Rectifier for V-12 Screen Supply
V-17	5R4-GY	Full-Wave Rectifier for 300 volt B+
V-18	5Y3-GT	Half-Wave Rectifier for B— supply to V-13
V-19	Mazda 120v. 3w. lamp	Bias control for V-5
V-20	368AS or 703A	Carrier Oscillator

SECTION III

OPERATION

CAUTION: Proper ventilation of the Model 84 is essential since it consumes over 200 watts. Under no circumstances should the ventilating louvres be obstructed either top or bottom while the instrument is in operation. When the Line Voltage Regulator is used, it should be kept away from the Signal Generator and ventilated as well.

1. INTERCONNECTING INSTRUCTIONS

Four detached cables are supplied with the Model 84. The following breakdown shows the correct cables to be used to interconnect the Model 84 with other units. Refer also to Figure 2:

(1) Cable "A" is used to connect the Model 84 output jack to the UHF equipment input jack.

(2) Cable "B" is an alternate, used when connecting the Model 84 to older types of UHF equipment.

(3) Cable "C" is used to connect the Model 84 Sync. Pulse Output to the external sync. input of a cathode-ray device.

(4) Cable "D" is used to connect the Model 84 to a standard sine-wave generator. Cables "C" and "D" are identical.

2. PRELIMINARY ADJUSTMENTS

a. Connecting To Power Source

(1) Plug the power cord into Line Voltage Regulator and connect the Line Voltage Regulator to a 117 Volt line having a frequency of exactly 60 cycles.

NOTE: If the line frequency is *not exact,* connect the equipment directly to the 117 volt AC line.

3. OPERATION

a. Carrier Oscillator Adjustments

(1) Select an unmodulated carrier by depressing the button marked "Off" in the vertical row of six Modulation Push-Buttons on the front panel.

(2) Turn on the equipment by snapping the power switch up, and allow a few minutes for the instrument to warm up.

(3) Check the Oscillator Filament Current ammeter reading. Some instruments have the proper filament current shown by a red band on the ammeter. Other have an engraved plate indicating the correct adjustment for the particular oscillator tube. This current may be regulated by means of a screwdriver adjustment located to the right of the ammeter.

(4) Connect the output and input cables required for the particular test. Figure 2 lists the various types of connectors which will be found on the four cables supplied with the Model 84. See also "Interconnecting Instructions" above, and "Carrier Output Connections," page 29.

(5) Set the carrier to desired frequency by means of the Coarse and Fine Carrier Frequency knobs, while reading the calibrated scale marked "Megacycles."

(6) Turn the Carrier Output control clockwise until the Output Meter indicates 100K (100,000 microvolts). Set the movable fiducial on the Output Dial opposite the 100K mark. Lower carrier levels at that particular frequency can now be obtained by counter-clockwise rotation of the Carrier Output Dial.

b. Applying Sine-Wave Modulation

If sine-wave modulation is desired, adjust the Per Cent Modulation Meter to zero, using the knob marked "Mod. Zero," while the "OFF" push-button is in. Then select the desired sine-wave frequency by depressing the button marked 400, 1,000, 2,500 or Ext. Advance the "Sync. In & Mod." control until the desired modulation level is indicated on the Per Cent Modulation Meter. With large changes in carrier frequency it is necessary to repeat steps "a(6)" and "b." Connection for external modulation is shown in Figure 2, (Cable "D").

c. Applying Pulse Modulation

If pulse modulation is desired, the "OFF" push-button should first be depressed in order to adjust the Carrier Output level as in step a(6).

Upon depressing the push-button marked "Pulse," the carrier will be switched on and off at a rate determined by the two Pulse Frequency controls. The indicated frequencies on the left hand Pulse Frequency dial are to be multiplied by the factors shown on the right hand "Multiplier" dial. The other two pulse dials are provided to control the pulse width and to delay the pulsed carrier with respect to the Synchronizing Pulse. (Refer to Supplementary Data page 30.)

d. Use of Synchronizing Input

The "Sync. In & Mod." knob can be used to apply an external synchronizing voltage to the pulse generator in cases where frequency stability of the pulses is important. Connection to the lower left hand jack is made by running one of the cables to an external frequency standard as shown in Figure 2. This connection will also provide for external sine-wave modulation of the carrier when the "Ext." push-button is depressed.

e. Use of the Synchronizing Pulse Output

The purpose of the synchronizing pulse is to "lock" the time-axis oscillators commonly used for observation of the pulse-modulated carrier. This assures a fixed starting point for the time-axis, from which the carrier pulses may be delayed by operation of the calibrated "Pulse Delay" dial, (see "Limits of Pulse Width and Delay," page 31). The Synchronizing Pulse is obtained from the upper left hand jack below the "Sync. Out" knob. Selection of a positive or negative synchronizing pulse is made by means of this knob.

CAUTION: When the Model 84 is not in use for extended periods the Line Voltage Regulator should be disconnected from the line voltage source, otherwise it will continue to consume power and may be damaged by overheating.

SECTION IV

THEORY OF OPERATION

The brief discussion of operating principles included in this section will treat separately with the Carrier Oscillator, the Sine-Wave Modulator, the Pulse Generator and their respective metering circuits and controls.

1. THE CARRIER OSCILLATOR

a. Oscillator Circuit

A Western Electric "doorknob" triode (Type 368AS or 703A) is operated in a modified "butterfly" tuning circuit. The resonance of anode-grid coupling is controlled by a single tunable element, shaped to provide a reasonably straight-line frequency distribution over the range from 300 to 1,000 megacycles. Though the effective length of the hand-calibrated carrier frequency scale is about nine inches this scale may be divided into more than 2,700 equal parts by means of the Fine Frequency dial and red counter scale. Precision tuning is facilitated by the use of split tuning gears, spring loaded, to provide a gear reduction having extremely low backlash.

b. Oscillator Filters

The necessary supply line to the three tube elements are passed through separate three-section U.H.F. filters and isolated from each other within the triple shields enclosing the oscillator assembly. These precautions have effectively confined all radiation to the attenuator system where it may be accurately controlled.

c. The Mutual Inductance Attenuator System

Carrier output is obtained from a transverse inductive coupling element attached to a coaxial line which can be moved in and out of the attenuator tube from the oscillator chamber. This movement is effected by a rack and pinion operated by the Carrier Output knob and results in an exactly logarithmic rate of attenuation. Though absolute accuracy of output measurement is difficult at ultra-high frequencies, it is important to realize that the above method of attenuation provides substantially perfect adjustment of carrier output levels insofar as their *relative* accuracy is concerned.

d. The Output Pad

Standing waves due to mismatch of even the most carefully designed connectors (such as the #49268 supplied with the Model 84) have been minimized by means of a 10 decibel pad built into the Output Jack and Crystal Assembly.

This pad is designed to provide constant insertion loss over the entire range of the instrument. The 10 db. loss is, of course, accounted for in the factory calibration of the output meter.

2. THE SINE-WAVE MODULATOR

a. The Sine-Wave Oscillator

The sine-wave oscillator included in the modulator section of the Model 84 operates on the resistance-tuned principle. Regeneration between the two tubes V-5 and V-1 (see Fig. 17) is controlled by the frequency selective network comprising C24, C25, R37 and R38. This network balances at 400 cycles, according to the formula: $f = 1/2\pi RC$, where R is the series or shunt resistor and C the series or shunt capacitor. Two pairs of resistors, R33, R34 and R35, R36 may be switched across R37 and R38, tuning the network to either 1,000 or 2,500 cycles. The selective network forms a regenerative path to the grid of V-5.

Another network, comprising C27 and R41, applies a degenerative voltage across the ballast lamp, V-19. The rapid increase in resistance of this lamp with respect to increases in feedback voltage tends to limit the oscillation to linear portions of the tube characteristics.

b. The Per Cent Modulation Metering Circuit

Measurements of per cent modulation are obtained by metering the a.c. component of carrier oscillator grid current.

Half-wave rectifier action occurs during positive excursions of the oscillator grid (V-20), this voltage being converted to pure D.C. at the termination of a three-section U.H.F. filter. D.C.

values from —20 to —60 volts, depending on carrier frequency, may be developed across the Modulation Zero potentiometer, R58, which terminates the grid filter.

The operation of setting the % Modulation Meter to zero (before modulation is applied) actually consists of balancing a portion of the negative grid voltage against a fixed positive voltage derived from the % Modulation Calibration potentiometer R63.

This manual adjustment of the potentiometer arm of R58 establishes a fixed "electrical zero" for the Per Cent Modulation Meter, regardless of the actual D.C. grid component across the entire potentiometer.

When modulation is applied, an alternating current of modulation frequency is superimposed on the steady oscillator grid current resulting from the carrier. Since the ratio of A.C. to D.C. grid current through R58 will be a direct function of the percentage of modulation, and the direct current applied to the meter is manually adjusted to a fixed value, it follows that a definite value of modulation voltage will be applied to the diode, V-2, for any given modulation level.

3. THE PULSE MODULATOR

a. The pulse circuits perform the two functions of pulsing the carrier and controlling an external time base. The two output pulses may be separated by as much as 50 microseconds, though operated from a common multi-vibrator source.

b. The two triode sections of V-9 are employed as a Multi-Vibrator in which the grid circuit time constants may be varied in steps by three pairs of matched capacitors, C4-7, C5-8 and C6-9, and between these steps by the dual rheostat, R12, thus controlling the pulse frequency over the range from 60 to 100,000 pulses per second.

c. The extremely sharp drop (or negative slope) characteristic of the multi-vibrator wave is transformed into a pulse at the input grid of V-10 by eliminating the steady-state, or "flat-top" portion of the wave. This process, commonly called "differentiation," results from the rapid discharge of the small capacity, C-10, through the grid resistance, R-15. This discharge is accelerated by mutual coupling between the two sections of V-10. These triode sections of V-10 are unbalanced in such a way as to discriminate in favor of negative pulses, hence the term "Negative Trigger."

d. After V-10 the circuit divides. The tubes V-7, V-11 and V-15 pertain to the Synchronizing Pulse only, whereas V-14, V-13 and V-12 are employed for switching the carrier oscillator, V-20.

e. In each branch an additional trigging tube (V-7 or V-14) receives the pulse from V-10 and applies it to a limiting amplifier (V-11 or V-13), and then to an output stage (V-15 or V-12).

f. Choice of either positive or negative Synchronizing Pulse polarity is provided by V-15, operating as a phase splitter. This output tube functions only on positive pulses, since it is biased nearly to cut-off during the intervals between pulses.

g. The Pulse Limiter, V-13, draws heavy current from a regulated B— supply (VR-105-30). As it is normally at saturation, the Pulse Modulation Output tube, V-12, will normally remain cut off, due to the large negative bias established across R56. This leaves the cathode of V-12 slightly negative to ground, preventing oscillation of V-20 (the U.H.F. Carrier Oscillator) since the anode of V-20 is connected through the push-button switch to the cathode of V-12. Application of a negative pulse to the grid of V-13 will reverse this condition, driving the cathode of V-12 so highly positive that full oscillation of the carrier will take place for the duration of the pulse.

h. The duration, or width, of the carrier pulse is dependent on the adjustment of R54 which controls the discharge time of C34.

i. In a similar manner the Delay Control, R48, varies the discharge time of C30. As the negative slope, or decay, of this pulse is delayed by advancing the Delay Control, the resultant square wave is again differentiated at the grid of V-13. By operating V-13 at saturation, only this delayed negative slope is amplified and a controllable time displacement of the pulse results.

j. The overall result of these operations is to "store" the pulse obtained from V-10 until the period of time indicated by the Delay Dial has elapsed. The pulse is then delivered to the grid of V-13 where it is again stored in C34. Until C34 can discharge through the Width Control, R54, the carrier oscillator will continue to function, since

the oscillator anode will be held positive by the cathode of V-12 until the current through R56 rises again to reestablish a cut-off basis for V-12.

4. THE POWER SUPPLY

Three separate high voltage supplies are included in the power supply assembly of the Model 84:

a. +325 volts for all anode (B+) operation, consisting of a full-wave rectifier, V-17, and choke input filter, the output of which contains less than 0.5% ripple when delivering 150 ma.

b. +425 volts, supplying the screen of V-12 from a full-wave rectifier, V-16, and filter. Good regulation is not required of this circuit.

c. —105 volts, a B— supply for V-13, derived from the half-wave rectifier, V-18, and regulated by V-3.

d. All modulator tube heaters are operated from one 6.3 volt winding of the power transformer. A separate 2 volt winding supplies the carrier oscillator filament (V-20).

e. The six 8 mfd. paper filter capacitors are oil filled. The power transformer, filter chokes and modulation choke are all thoroughly potted and conservatively operated.

5. THE LINE VOLTAGE REGULATOR

The Line Voltage Regulator will maintain a constant output of 117 volts within less than 1%, for line voltage variations of 10% or more. This regulation, however, depends on a stable *supply frequency* of exactly 60 cycles per second. If the power source frequency is uncertain it is advisable to connect the Model 84 directly to the power line.

FIGURE 3—TOP VIEW WITH CASE & DIAL COVER REMOVED

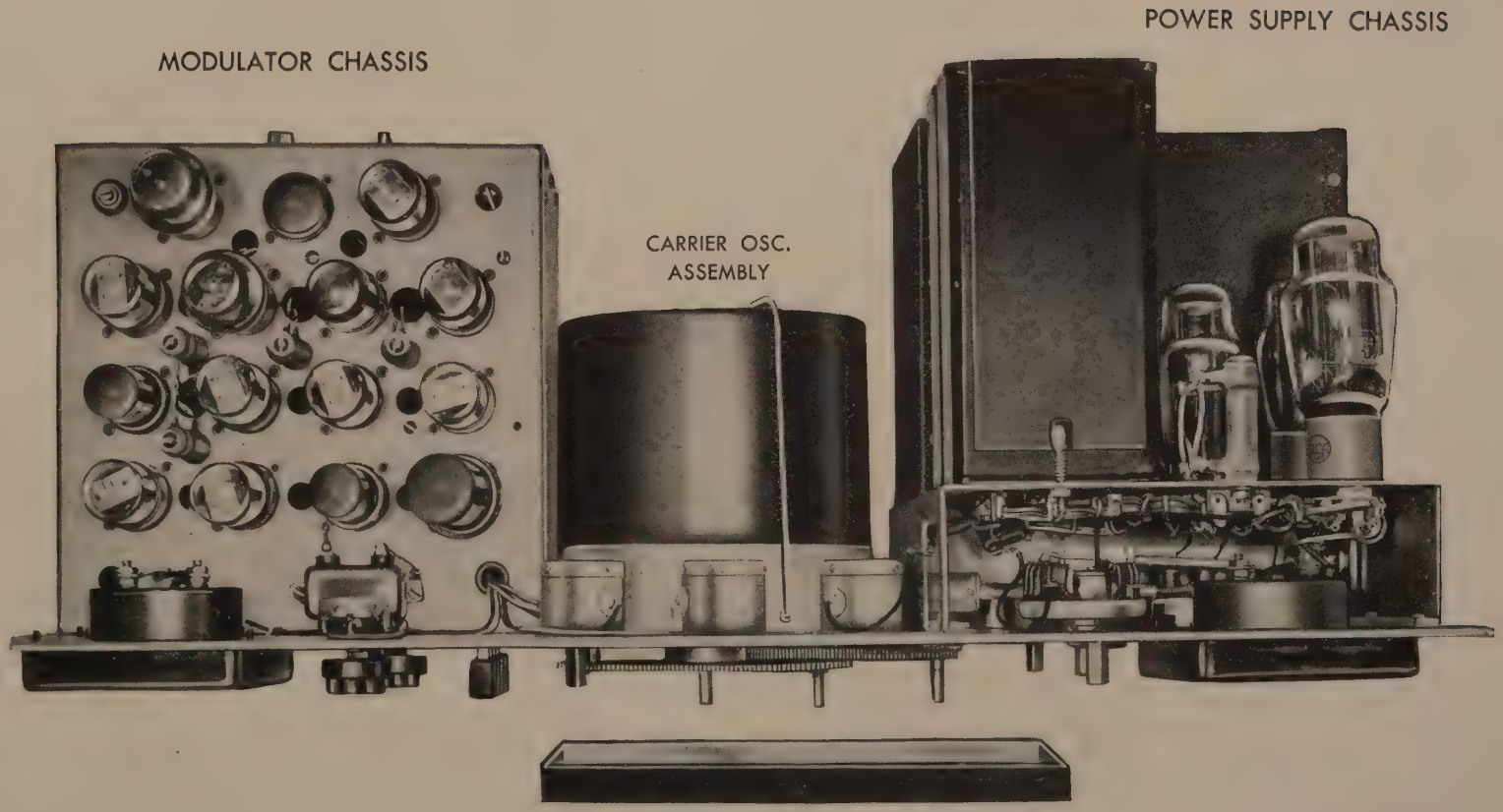


FIGURE 4—REAR VIEW OF ASSEMBLY

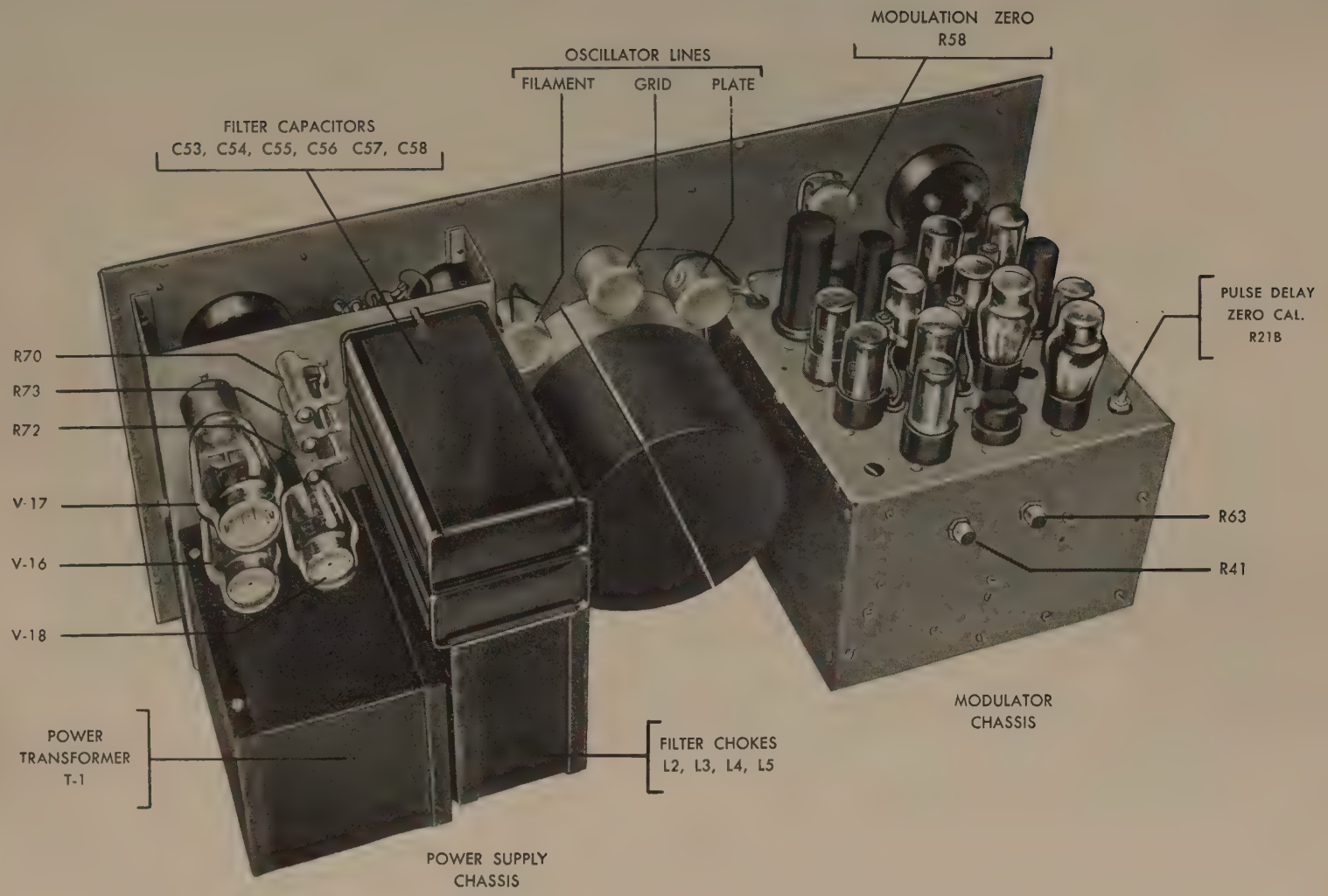


FIGURE 5—REAR VIEW OF CHASSIS WITH POWER SUPPLY & SHIELDS REMOVED

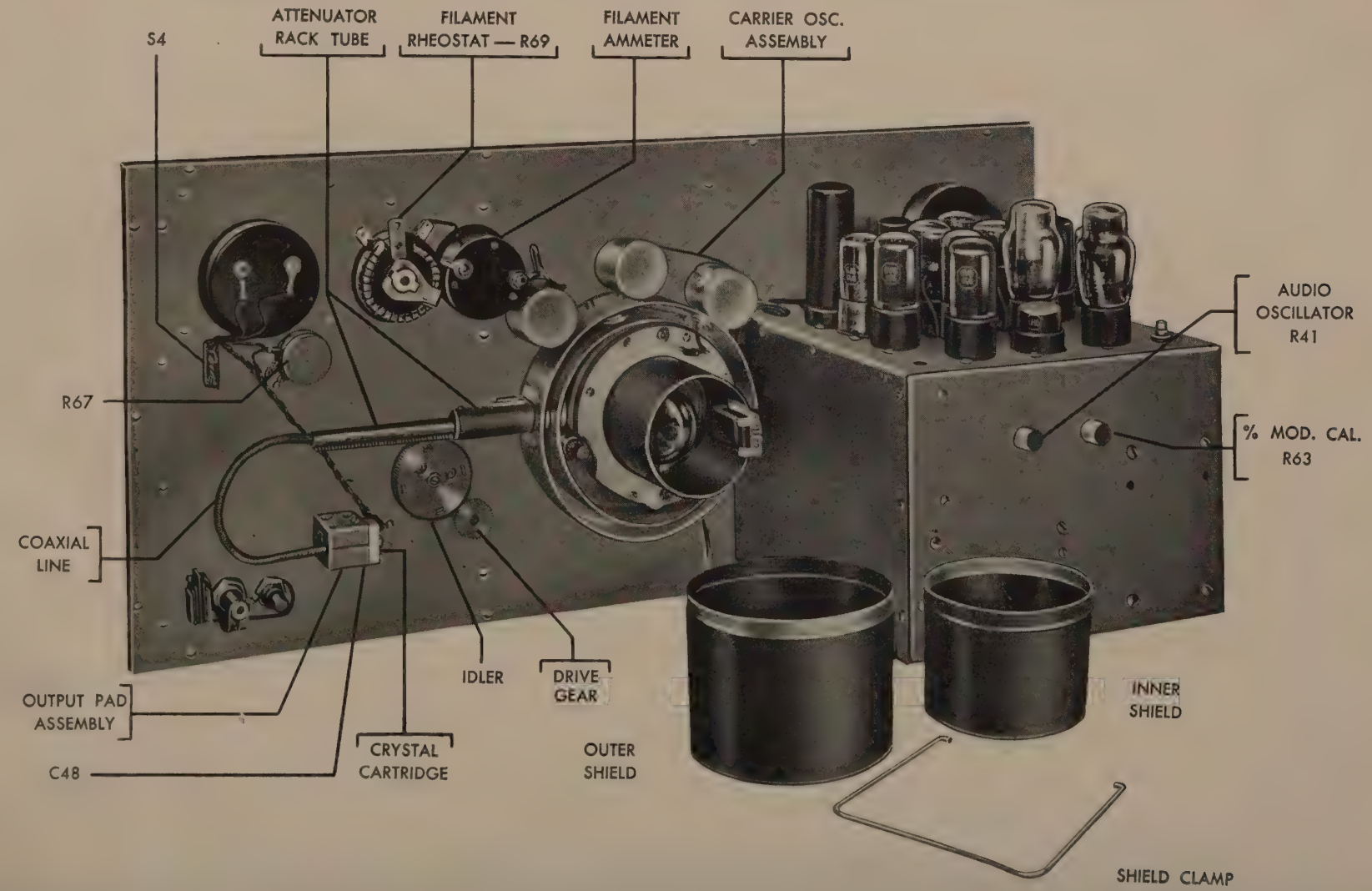


FIGURE 6—AREA UNDER DIAL COVER

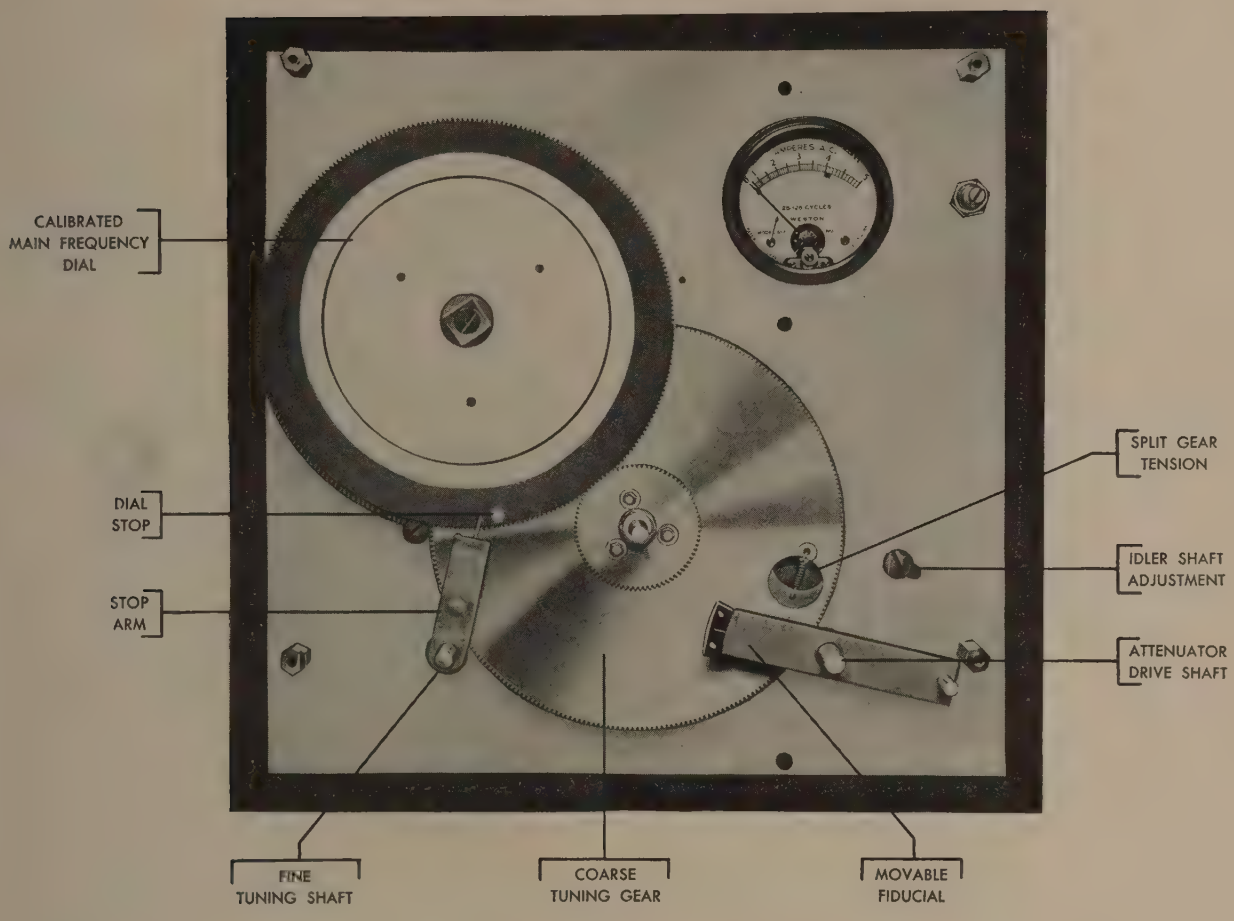


FIGURE 7—CARRIER OSCILLATOR ASSEMBLY

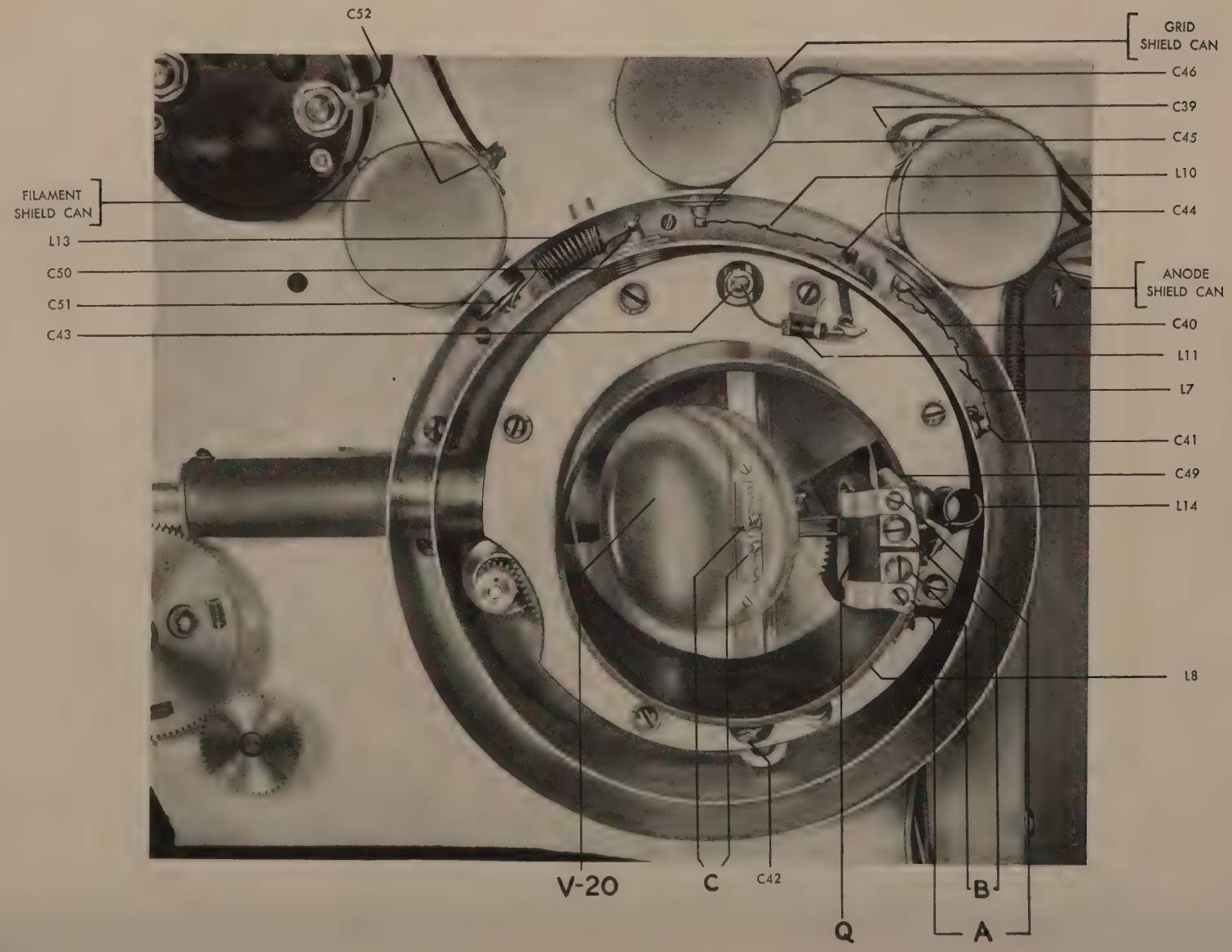


FIGURE 8—POWER SUPPLY—FRONT VIEW

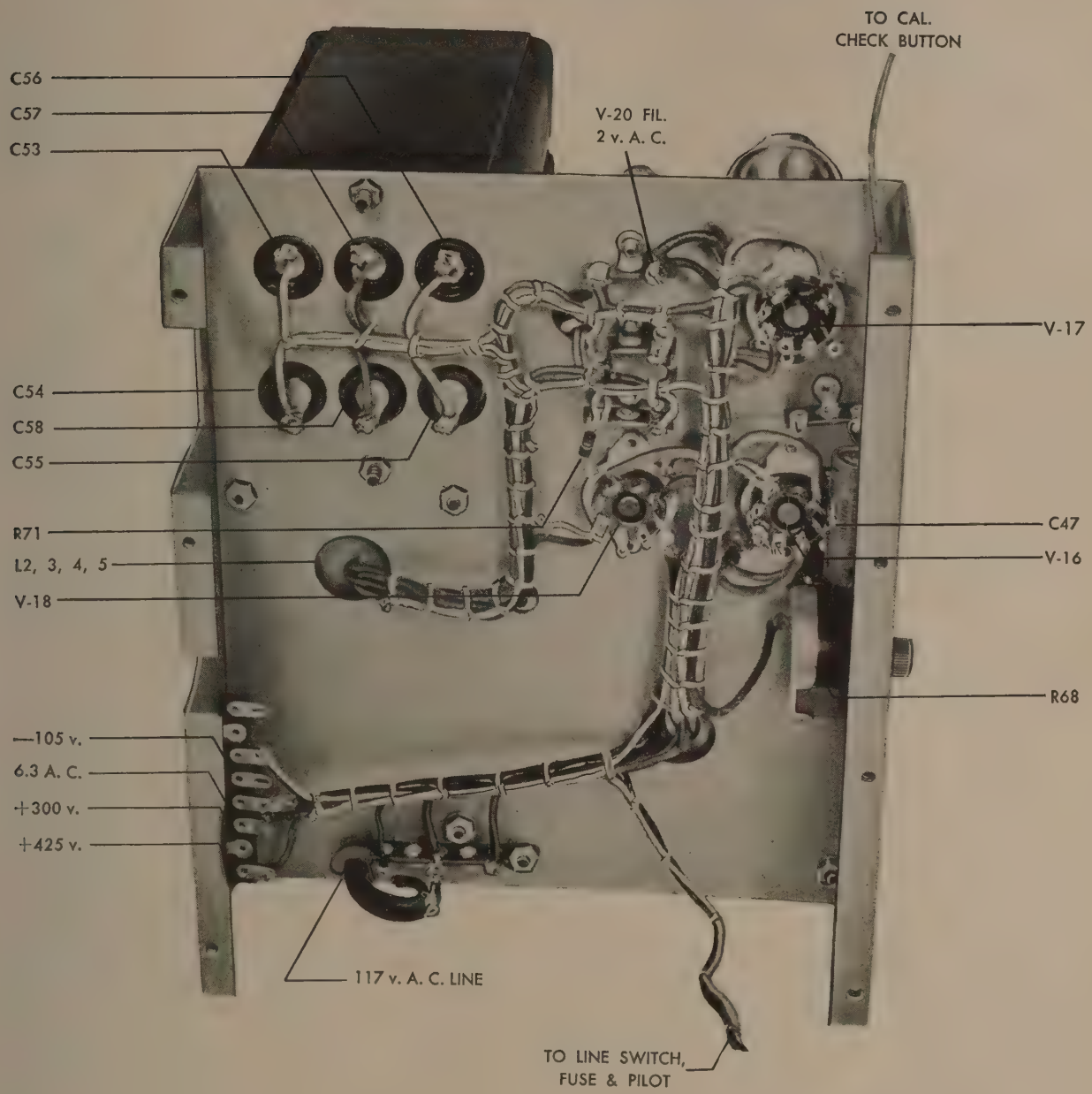


FIGURE 9—MODULATOR CHASSIS TUBE LAYOUT DIAGRAM

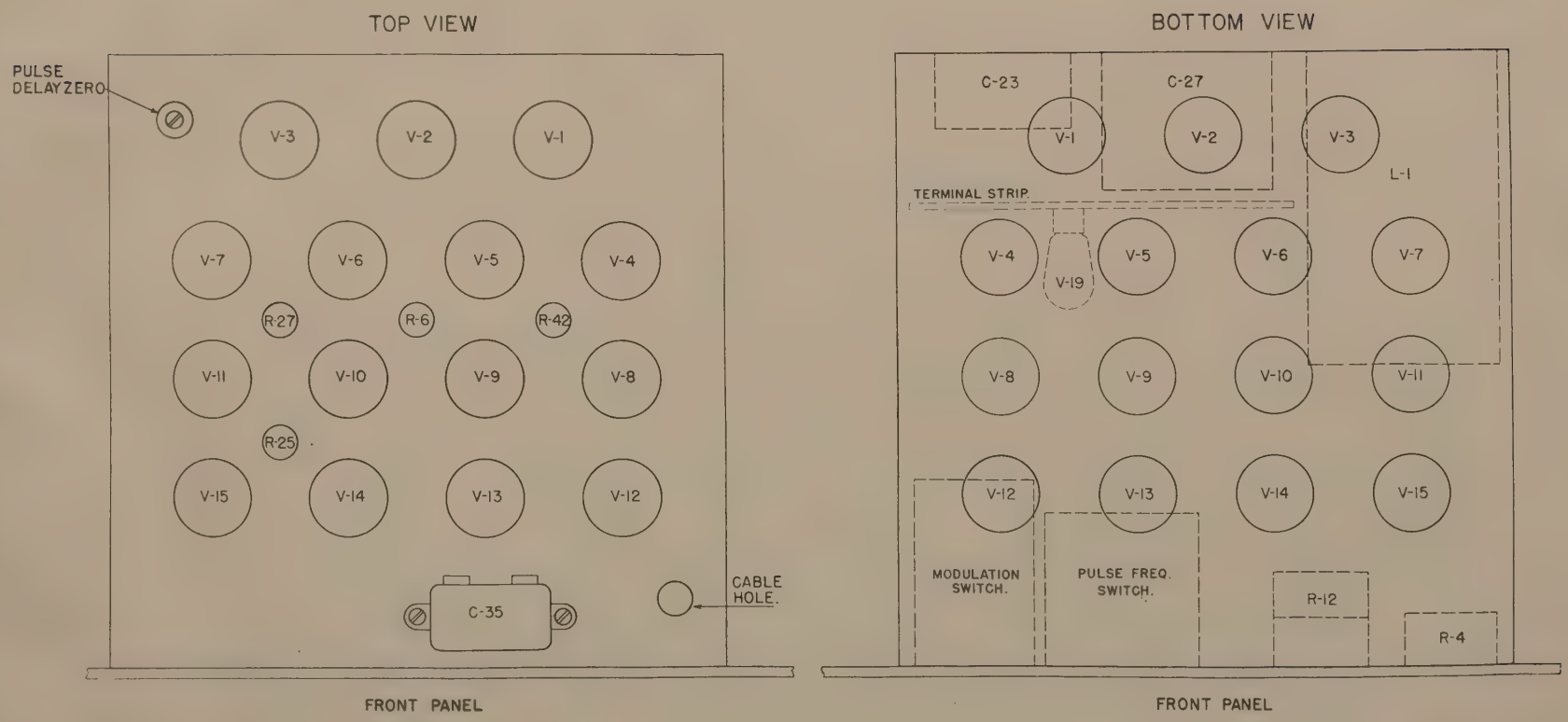
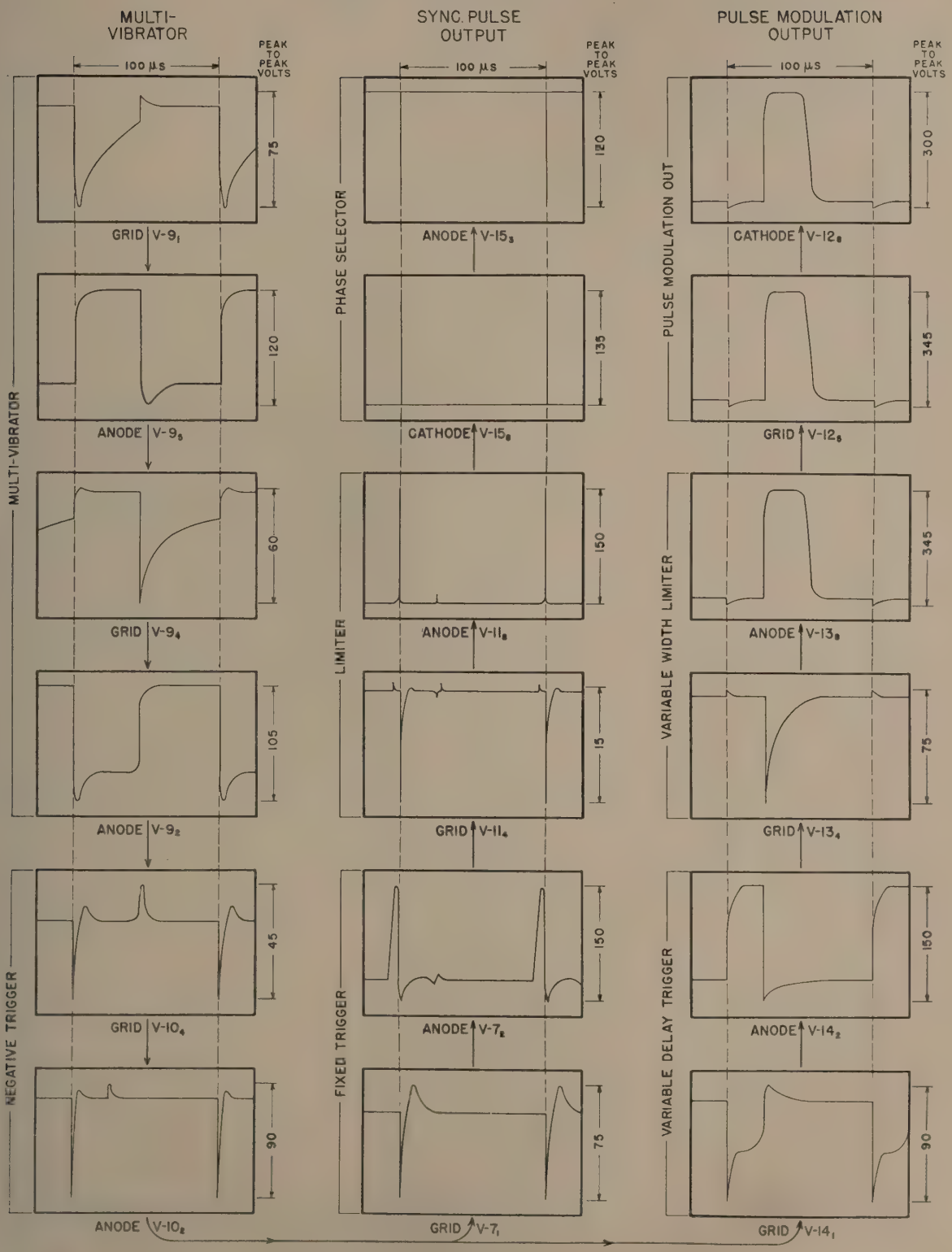


FIGURE 10—PULSE CHART



NOTE- REPETITION FREQUENCY = 10,000 (X 100 RANGE)
DELAY = 25µS
WIDTH = 30µS

FIGURE 11—CRYSTAL MODULATION DETECTOR SUGGESTED FOR TEST AND DEMONSTRATION OF THE MODEL 84 WHEN A RECEIVER IS NOT AVAILABLE

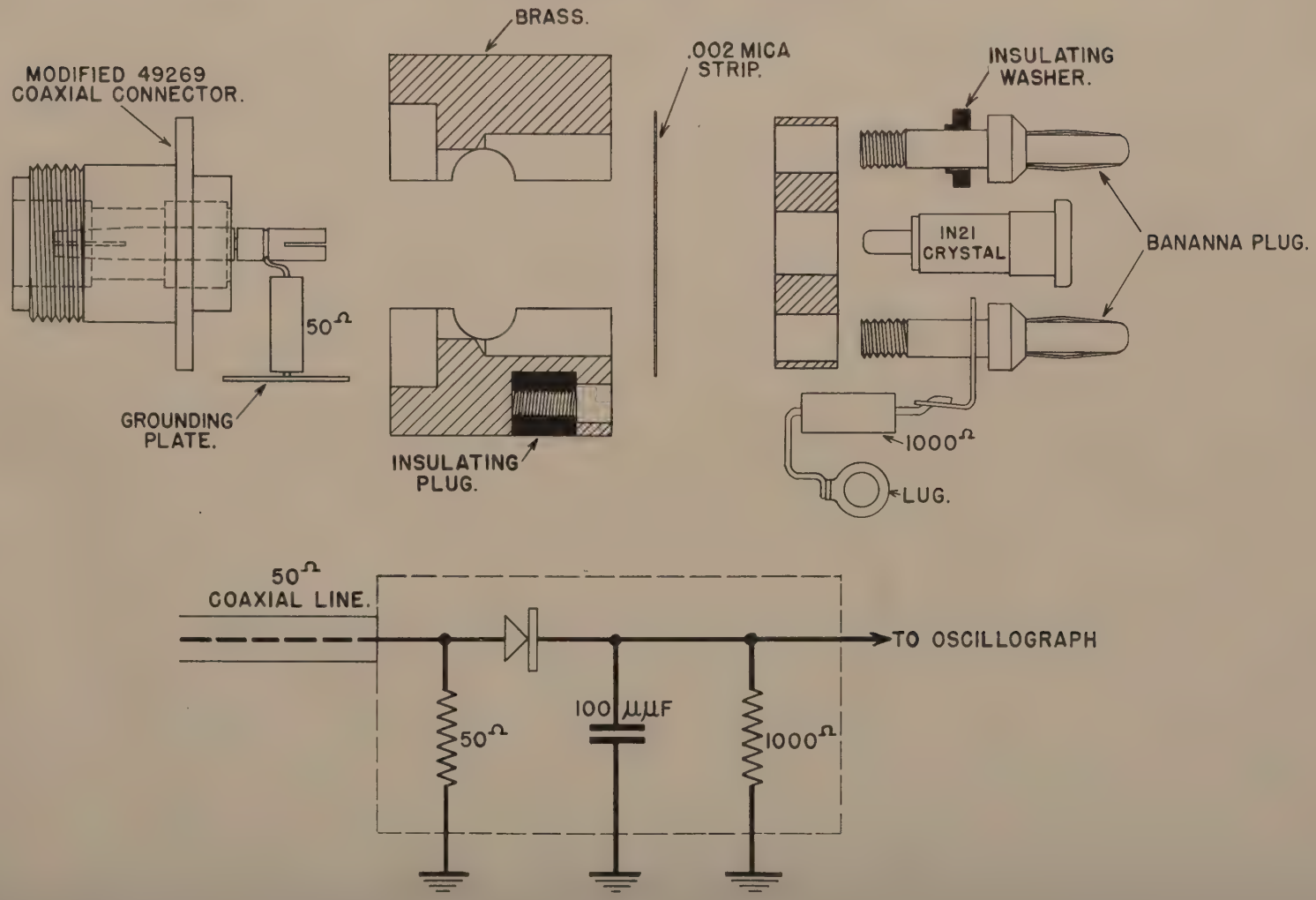
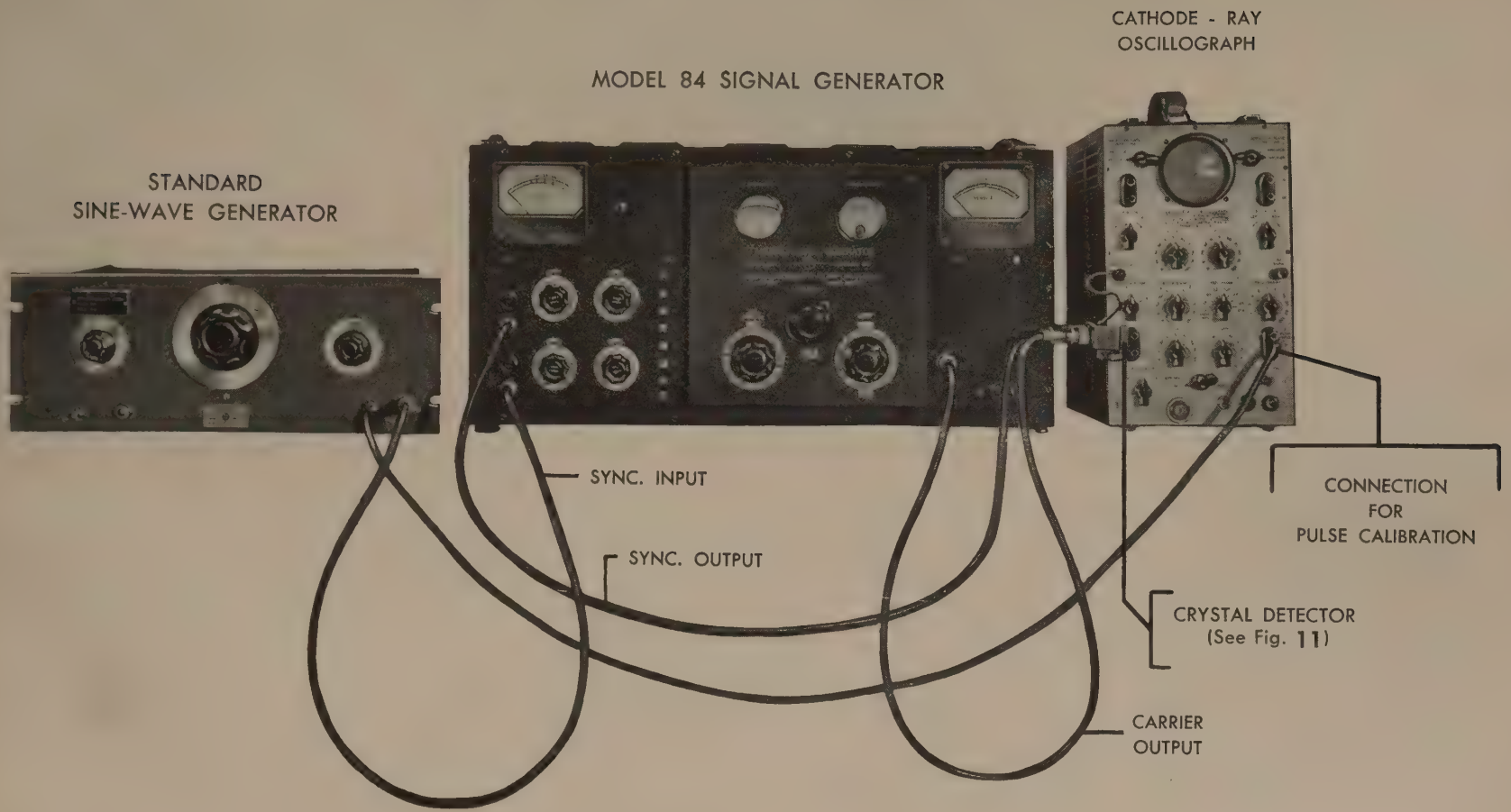


FIGURE 12—CONNECTIONS TO TEST EQUIPMENT



D.C. TUBE VOLTAGE CHART*

NOTE: These approximate voltages to ground will be obtained with the Pulse Frequency Switch open (between two ranges) and all other modulator controls in counter-clockwise position. The Push-Button Switch should be as shown in the third column under "Modulation."

NO.	TUBE TYPE	MODU-LATION	ANODE PIN	ANODE VOLTS	SCREEN PIN	SCREEN VOLTS	GRID PIN	GRID VOLTS	CATHODE PIN	CATHODE VOLTS	ANODE SUPPLY
1	6V6-GT	2500	3	145	4	170	5	0	8	12	+300
2	6H6	2500	3-5	−.5	...	...	...	...	4-8	ground	...
3	VR105-30	any	5	ground	...	...	...	...	2	−105	−200
4	6V6-GT	2500	3	275	4	300	5	0	8	15	+300
5	6SJ7	2500	8	80	6	35	4	0	5	1.6	+170
6	VR150-30	Pulse	5	150	...	...	...	...	2	ground	+300
7	6SN7-GT	Pulse	2	165	...	...	1	58	3	58	+300
"	"	"	5	300	...	...	4	20	6	58	"
8	6J5	2500	3	135	...	...	5	0	8	6	+170
"	"	Pulse	"	180	...	...	"	0	"	8	+240
9	6SN7-GT	Pulse	2	75	...	...	1	0	3	ground	+150
"	"	"	5	75	...	...	4	0	6	"	"
10	6SN7-GT	Pulse	5	85	...	...	4	24	6	24	+150
"	"	"	2	150	...	...	1	11	3	24	"
11	6AG7	Pulse	8	30	6	95	4	0	5	ground	+300
12	6L6	Pulse	3	300	4	425	5	−60	8	−10	+300
13	6AG7	Pulse	8	−60	6	−12	4	−105	5	−105	−105
14	6SN7-GT	Pulse	2	165	...	...	1	58	3	58	+300
"	"	"	5	300	...	...	4	20	6	58	"
15	6J5	Pulse	3	270	...	...	5	0	8	12	+300
16	5Y3	Pulse	4-6	1100 rms	...	...	...	...	2-8	5 rms	...
17	5R4	Pulse	4-6	1100 rms	...	...	...	...	2-8	5 rms	...
18	5Y3	Pulse	4-gr.	260 rms	...	...	...	...	2-8	5 rms	...
19	Mazda 120v. 3w.	2500	...	...	...	...	...	...	base to gr.	1.5 (D.C.)	...
20	368-AS or 703-A	Off	red	275 (DC)	...	...	green	−20–70	Q-gr.	2	300

*** The voltmeter used should have a resistance of 5,000 ohms or more per range-volt. Deviations of ±10% from the above voltages are not serious, except at the regulator tubes, V-3 and V-6, which should come within ±5%.**

SECTION V

MAINTENANCE

NOTIFICATION: In the event of failure of any of the functions of the Model 84 Signal Generator the Measurements Corporation should be notified at once. The instructions in this section are to be applied only when return of the instrument is not feasible. In many cases correspondence with the Measurements Corporation will provide a practical solution to the difficulty which will save the time and handling involved in returning the instrument to the factory. However, returned instruments will receive prompt attention, including complete performance tests and recalibration, if necessary.

1. GENERAL INSTRUCTIONS

a. Packing for Return Shipment

(1) The original Model 84 shipping crates should be used when possible as they provide double shock protection on all sides of the instrument. A substitute packing case must include a special frame to protect the panel controls from direct contact with the case. Fasten felt or sponge rubber pads securely on all sides of the Model 84 and, preferably, use a strong outer case lined with shock absorbent material.

b. Maintenance Precautions

(1) It is strongly recommended that a complete analysis of any trouble be made, preferably in writing, before attempting repairs in the field. The Model 84 is provided with three meters and nineteen controls, all conveniently located on the panel. Much trouble shooting can be done by means of these controls.

(2) The following paragraphs will explain some possible causes of abnormal indications and their cures. Once the complete facts on performance are known, it may or may not be necessary to undertake the rather difficult operation of removing the instrument from its case (as described below).

c. Removing the Model 84 from Its Case

(1) Fourteen screws along the outer edge of the panel must first be removed. Rotate the movable fiducial until its handle is above the Carrier Output Dial (to prevent damage to the handle). Now tip the instrument forward, while supporting the panel firmly, and pull the case away from the panel.

(2) Though it is often convenient to up-end the instrument so that it rests on the power supply, this should only be done after supporting blocks have been wedged between the modulator and power supply chassis to prevent undue strain on the panel assemblies.

d. Test Equipment Used—Figure 12 shows three items of test equipment used for preliminary factory inspection of the Model 84. Their specifications are as follows:

(1) The *Oscillograph* should have "video" range amplifiers with satisfactory square-wave response at 100 kc, and a deflection sensitivity of at least .01 rms. volts per inch over the range of 20 cycles to 2 megacycles.

(2) The *Sine-Wave Generator* should have good frequency calibration from 50 to 100,000 cycles and an output of at least 4 rms. volts.

(3) The *Crystal Detector* may not be necessary if other U.H.F. receiving equipment is available. For construction of a simple detector with 50 ohm termination see Figure 11.

e. Tube Replacement—The Model 84 contains 20 vacuum tubes. Sixteen of these may be replaced from standard tube stocks, but the four tubes listed below will require careful selection in order to avoid calibration errors:

(1) V-20 (368-AS or 703-A). See page 23 for instructions on removal and replacement.

(2) V-19 (Mazda 110-120 volt, 3 watt lamp, with candelabra base). See page 25 for replacement data.

(3) V-9 (6SN7-GT). See page 27 for method of checking pulse frequency calibration.

(4) V-2 (6H6). See page 26 for % Modulation recalibration, etc.

2. CARRIER OUTPUT FAILURES

CAUTION: Under no circumstances should the carrier oscillator assembly be disturbed until every other possible source of trouble

has been investigated. Repairs to the oscillator assembly, other than replacements of V-20, are not likely to be successful in the field.

a. Analysis

(1) Failure to obtain carrier output from the Model 84 may, of course, be due to faults in the receiving equipment or in the connections used. These causes should be definitely eliminated before suspecting the signal generator. If the Modulation Meter zero varies in a normal manner while tuning over the carrier range, it is probable that the oscillator is functioning, regardless of any other condition, such as absence of signal from the output jack, or inability to obtain readings on the Carrier Output Meter.

(2) The following checks should be made if the carrier oscillator is suspected of faulty operation:

CARRIER OUTPUT FAILURE

Preliminary Analysis

Meter Indications	*Possible Causes*
Filament ammeter deflects *above* full scale.	Filament of V-20 grounded.
% Modulation Meter reads *below* mechanical zero*	Filament of V-20 open, or grid of V-20 grounded.
% Modulation Meter will not come up to zero and will not increase when sine-wave modulation is applied.	Filament and grid of V-20 shorted together.
% Modulation Meter remains fixed slightly *above* mechanical zero* (due to contact potential of V-2).	V-17 (300 volt rectifier) defective, or shorted B+.

(3) The Carrier Output and Modulation meters can always be checked against each other. If one meter is functioning properly and not the other, the carrier oscillator cannot be defective. If both meters are inoperative the oscillator supply lines, shown in Figure 4, can be checked. The black lead supplies the 1.2 volt a.c. filament; the green (grid) lead ordinarily has a potential of 30 to 60 volts negative to ground, depending on the carrier frequency; the blue lead should show about 300 volts positive for normal anode supply with the "OFF" push-button depressed.

(4) Since both anode and grid leads to the carrier oscillator are routed through various circuits in the modulator it may be desirable to disconnect these leads in order to check the carrier oscillator separately. Merely remove the grid lead (green) at the grid shield can (see Figure 7) and the anode lead (blue) at the anode shield can. While these leads are disconnected it would be well to check the anode and grid for shorts with an ohmmeter. Then connect a 5,000 ohm resistor from the grid terminal to ground and bring a 300 volt B+ line directly from the power supply to the anode terminal. The red lead on R73 (see Figure 8, Power Supply Chassis) is a convenient 300 volt source. If necessary, the voltage drop across a 500 ohm resistor placed in series with the oscillator anode can be used to indicate the presence or absence of anode current, since an arcing condition in one of the oscillator plate by-pass condensers might cause damage to a milliammeter.

(5) With the above connections, lack of carrier output will be directly traceable to the oscillator. All tests should, of course, be made with the "OFF" push-button depressed, and with various

** "Mechanical Zero" is the normal rest point of the meter when disconnnected, as distinguished from "Electrical Zero" to which the meter is set by means of the Modulation Zero control.*

filament current adjustments. Before inserting a new oscillator tube (see instructions below) a continuity check of the anode and grid filters is advisable.

b. *Replacement Of The Carrier Oscillator Tube (V-20)*

(1) Errors in the hand-calibrated frequency dial may occur when V-20 is replaced. If facilities for ultra-high-frequency calibration are available, a correction chart can be prepared, using the *red* numbers on the Carrier Frequency Dial, in conjunction with the subdivisions of the Fine Frequency Dial.

(2) To remove V-20, the following sequence should be observed. Figure 7 shows the parts referred to below.

WARNING: Take every precaution to prevent dirt from dropping into the oscillator assembly.

(a) Withdraw the Model 84 from its case while in its normal position. (Refer to page 21, paragraph c.)

(b) Remove the "bucket bail" clamp securing the outer shield can. Remove outer and inner cans by twisting until their friction bonds are broken.

(c) Loosen screws "A" and push aside the clamps which support "Q."

(d) Loosen screws "B" and pull "Q" gently toward V-20 to separate it from its supporting mount.

(e) Observe the two clamps "C" which secure the grid and plate prongs of V-20. The tube can now be removed *without disturbing any other screws,* by rocking it gently while pulling slowly in a direction parallel to its axis (i.e.—away from the oscillator base, but to the left).

(f) While tube is out, brush out any loose particles deposited in the cylindrical portion of the upper chamber.

(g) Loosen set screws which secure "Q" to the filament prongs of V-20. Select a new tube, type 368AS or 703A, and connect it to "Q," tightening the set screws firmly.

(h) Insert plate and grid prongs of the tube into clamps "C." Locate the *lower* pin first while it can still be seen, then align the upper pin and press the tube while rocking it slightly. If difficulty is experienced, withdraw the tube and make sure that clamps "C" are *exactly parallel.* Forcing may crack the tube or cause irreparable damage to the mounting bars.

(i) Replace the prongs of "Q" in its mount, align clamps over "Q" and tighten screws "A" and "B."

(j) Tip the Model 84 on its back and tap upper chamber to clean out any loose particles.

(k) Before replacing shields, etc., the new tube should be checked for performance over the entire carrier frequency range, with the filament current most suitable for the particular tube. Refer to page 28, paragraph a., "Oscillator Filament Adjustment."

(3) The following factors of performance are affected by replacement of V-20.

(a) *Parasitics:* A compromise adjustment of filament current must be made (refer to page 28, paragraph a.) to minimize this condition.

(b) *Output:* A tube requiring a high filament current to deliver the required output may tend to generate parasitic oscillations and should be rejected. *Uniformity* of oscillator operation can be conveniently checked by measuring the negative voltage at the oscillator grid terminal (see Figure 4). This should not be more than —70 volts. nor less than —15 volts at any carrier frequency.

(c) *Pulse Modulation:* If important, the "initial delay" or inertia of the pulses of carrier may be checked at a pulse rate of 100 kilocycles. (Refer to page 31, paragraph f.). A 300 megacycle carrier should not require more than four microseconds to get started and a minimum pulse width of three microseconds should be obtainable.

(d) *Calibration Errors* due to a replacement of V-20 should be checked after an acceptable tube has been inserted and the oscillator shield cans have been replaced.

c. *Lack of Carrier Output Control*

(1) If the carrier level cannot be controlled by the carrier output knob, the trouble may be either mechanical or electrical.

(a) Mechanical slippage in the knob itself is easily remedied, but disengagement of the idler gear (see Figure 5) may have damaged the attenuator loop by allowing it to strike the lower chamber of the oscillator.

(b) It is advisable to inspect this attenuator loop after any repairs to the attenuator mechanism.

Figure 5 shows the arrangement of these parts. The attenuator rack is aligned by means of a plug in the end of the attenuator tube. To inspect the loop, remove the idler gear and the set screw securing the plug. The rack carrying the coaxial line should then be carefully withdrawn from the tube so as not to cause further damage to the loop.

(c) This "loop" is actually a straight portion of #16 enameled wire across the end of the plunger. The enamel should not show evidence of wear from scraping the side walls of the attenuator tube. When reinserting the plunger, see that the stop pins on the idler gear are arranged to check the loop 1/16 inch before it reaches the wall of the lower chamber on its inward traverse. Do not allow it to contact the lower chamber at any time in the assembly operation.

d. Hum Modulation

Since AC is supplied to the filament of the carrier oscillator tube (V20), some hum ripple results in the carrier. This is chiefly frequency modulation. Its magnitude is approximately 40 kc, peak-to-peak, at 400 megacycles. If this order of frequency modulation is objectionable it may be necessary to supply the filament from a large two volt battery cell. For this the Model 84 must be partly removed from its case (see instructions on page 21) and the lead from the power supply to the oscillator filament rheostat disconnected. Run a heavy lead from this point to the battery by way of the line cord hole in back of the case. Another heavy lead from the battery should be grounded at a convenient point on the power supply chassis.

e. Crystal Replacement

(1) The Carrier Output Meter is operated by a Sylvania Type 1N21 crystal located on the Carrier Output Pad and Crystal Assembly (see Figure 5). If at any time a large adjustment of the Output Calibration screw driver control is required, this crystal is probably defective and should be replaced.

(2) The Model 84 must be removed from its case (see page 21) and up-ended, so as to rest on the power supply.

(3) The crystal is secured by a Bristo set-screw (#6), accessible from the panel side of the crystal holder. Before inserting a new crystal, grasp the panel firmly with one hand to discharge any body static which might damage the crystal. After securing a new crystal with a Bristo wrench, return the Model 84 to a horizontal position, turn the Output Dial counter-clockwise, and depress the Calibration Check Button. The Output Meter can now be set to the 100K mark by adjustment of the screw driver Output Calibration control below the meter, while holding down the Check Button. Since crystal replacements have little, if any, effect on the reference voltage, no further adjustments are necessary.

3. SINE-WAVE MODULATOR MAINTENANCE

When sine-wave modulation is applied by depressing a push-button marked 400, 1,000 or 2,500 and advancing the "Sync. In & Mod." gain control, it is normal for the Carrier Output Meter reading to *decrease* slightly.

In cases of apparent lack of modulated carrier output, the above check will show that associated receiving or indicating equipment is probably at fault. Failure to obtain this indication, however, may be investigated as follows:

MODULATOR FAILURE

Preliminary Analysis

Abnormal Meter Indications	*Possible Causes*
% Modulation Meter inoperative on 400, 1,000 and 2,500 but normal when 2 rms. volts is applied for "EXT." modulation.	Suspect V-19, V-1 or V-5 (sine-wave oscillator tubes).
% Modulation Meter also inoperative when using external modulation.	Suspect V-4 or V-8 (sine-wave amplifier tubes).
% Modulation Meter *decreases* when sine-wave modulation is *increased.*	V-2 (6H6) probably defective. See instructions on page 26 for replacement data.

a. Replacement of V-19

(1) This replacement should not be undertaken unless all other causes have been investigated, as these lamps are operated far below their normal current rating.

(2) V-19 may be observed through the ventilation holes beneath the modulator chassis after removing the Model 84 from its case. This lamp should glow slightly when the screw-driver control, R41 is adjusted for maximum feedback (see "Modulation Distortion," par. c.). Standard 3 watt, 110-120 volt lamps do not always have the required regulating characteristics and it may be necessary to try several.

b. Unstable Sine-Wave Modulation

An unstable modulation oscillator will cause rapid fluctuations of output resembling the familiar "motorboating" effect of an unstable amplifier. "Motorboating" of the sine-wave oscillator can be remedied in the field by removing *all* the lacing cord which secures the leads in the modulation unit and spacing these leads slightly. If necessary, the "Audio Osc. Cal." rheostat (R41) may be readjusted according to the instructions under "Modulation Distortion," par. c. Model 84's with serial numbers 97 to 142, inclusive, occasionally developed leakage in the grid circuit of V-1 which would upset the operation of the sine-wave modulation oscillator. This trouble is most likely to occur when the instrument has been standing idle for some time in a damp atmosphere and may disappear as the instrument heats up. If leakage is present it will cause a positive potential of from 1 to 10 volts to appear between the control grid of V-1 (pin 5) and ground, when measured with a D.C. vacuum tube voltmeter. This tube is the 6V6-GT nearest the "Audio Osc. Cal." rheostat on the rear of the modulator chassis, the leakage occurring at the green (grid) lead to pin 5.

c. Modulation Distortion

(1) If 30% sine-wave modulation cannot be obtained without distortion it is well to connect an external sine-wave generator to the jack below the "Sync. In & Mod." knob. With the "EXT." push-button depressed and about 3 rms. volts applied to this jack it should be possible to turn up the "Sync. In & Mod." control until 30% undistorted modulation is obtained. Try various carrier frequencies and oscillator filament current adjustments, as distortion can be caused by parasitics due to excessive filament current, or carrier non-linearity if the filament current is too low. If distortion is *only evident* when using the internal sine-wave oscillator it will be necessary to remove the case (see page 21) and try varying the amount of oscillator feedback.

(2) Screw-driver adjustment of rheostat R41 will control the amount of feedback power supplied to the ballast lamp, V-19. This feedback rheostat is mounted on the rear of the modulator chassis and labeled "Audio Osc." (see Figure 5). Make certain that the adjacent control marked

"% Mod. Cal." is protected by tape or a cap nut, so that it will not be disturbed accidently.

(3) To adjust for minimum distortion, R41 should be turned *counter-clockwise.* The push-button switch should then be operated in order to check the sine-wave oscillator stability. If too much feedback has been applied, the sine-wave output will waver for awhile after being switched on. This can be corrected by *clockwise* rotation of R41 to decrease the amount of feedback. It is best to set R41 well below the point where wave-form distortion becomes evident.

d. V-2 (6H6) Replacement

(1) As the individual emission characteristic of this diode will determine the proper setting of the % Modulation Calibration Potentiometer (R63), it will be necessary to age a replacement tube for at least 48 hours under operating conditions in order to stabilize its emission. Recalibration of the % Modulation Meter can be undertaken as follows:

(a) After removing the case (see page 21) connect high resistance AC and DC voltmeters in parallel between the *green* lead on R58 (Mod. Zero) and ground. Use the negative DC voltmeter connection.

(b) With the "OFF" push-button depressed, select a carrier frequency such that exactly —40 volts is indicated by the DC voltmeter.

(c) With the new diode (V-2) in place, adjust the % Modulation Meter to zero.

(d) Depress the "1000" push-button and advance the "Sync. In & Mod." knob until the AC voltmeter reads exactly 8.48 rms. volts.

(e) Repeat operation b, c, and d if necessary, with various 6H6 tubes until the % Modulation Meter indicates approximately 30%.

(f) Age the selected tube at least 48 hours before proceeding.

(g) Repeat steps c and d while correcting any error in the % modulation reading by adjusting the screw-driver potentiometer (R63) marked "% Mod. Cal.," located in the rear of the Modulator Chassis. For a low reading, R63 should be adjusted to *lower* the pointer still further. Then repeat steps c and d, leaving the AC level at 8.48, and correct the adjustment of R63 again, if necessary.

(h) If desired, the accuracy of the % Modulation Meter may be checked at other carrier frequencies by applying the factor .212 to the various DC grid voltage readings. This will give the proper rms. value of oscillator grid voltage required for 30% modulation.

4. PULSE MODULATOR MAINTENANCE

a. Analysis

To determine whether normal pulsing of the carrier is taking place, the following checks can be made:

(1) Check the "continuous wave" operation of the carrier at 800 mc. by depressing the "OFF" push-button and advancing the Carrier Output Dial. If no output meter deflection can be obtained, adjust the filament current between 3.9 and 4.5 amperes, then, if necessary, make the checks suggested under "Carrier Output Failures," page 22.

(2) If the carrier output is normal, set the Pulse Frequency controls for 10,000 by turning the Frequency dial to 100 and the Frequency switch to X 100. Depress the push-button marked "Pulse."

(3) Set the Pulse Delay to 0 and advance the Pulse Width Dial.

(4) If the Carrier Output Meter deflects as the pulse width is increased, it can be assumed that normal pulsing of the carrier is taking place. If not, the Model 84 will have to be removed from its case and placed upside down, and the usual signal tracing procedure followed, using a cathode-ray oscillograph.

(5) The normal continuity of pulse signals is shown in Figure 10, while the static operating voltages (with Frequency switch *open*) are given in the chart on page 20.

(6) It is convenient to commence signal tracing at the Pulse Frequency switch, where the grid and anode leads from the Multi-Vibrator are easily accessible. The Multi-Vibrator output can be checked first by observation with the oscillograph, however the most frequent tube failures occur in the more heavily loaded output tubes, V-12 and V-13. If the pulse disappears after the grid of V-13 (pin 4), the defective tube can be quickly located by connecting a D.C. voltmeter to the cathode of V-12 (pin 8). With the Frequency switch *open* (between two ranges), the normal potential at this point will be from 10 to 20 volts

negative to ground. If V-12 is dead, this voltage will be about —100, while if V-13 is dead it will be about +250.

b. Method of Checking Pulse Frequency Calibration

(1) Though replacement of the multi-vibrator tube, V-9 (6SN7), is not likely to cause serious errors in the Pulse Frequency dial calibration, methods of checking this calibration are described because of their general importance in the determination of pulse repetition frequencies.

(2) Figure 2 illustrates the method of connecting a standard sine-wave generator to the Model 84, and to the horizontal axis of a cathode-ray oscillograph to replace the usual linear sweep. Though the pulse circuits may be synchronized to the sine-wave generator by means of the "Sync. In & Mod." control, this synchronizing signal should, of course, be removed when making final adjustments of the pulse repetition frequency.

(3) When using a sine-wave sweep, care should be taken to find the highest pulse frequency that will produce a single pulse on the cathode-ray tube screen. Pulse rates which are *submultiples* of the sine-wave frequency are easily mistaken for the 1:1 ratio figure. To avoid this error during pulse frequency checks, adjustments should be verified by reducing the sine-wave frequency momentarily to one-half the desired pulse frequency and noting whether the correct double pulse pattern is evident.

(4) It is usual to select two or three frequencies within the X 10 range, such as 600, 2,000, and 10,000, and measure the "range error" when switching the Frequency Multiplier to X 1 and X 100. Various V-9 replacement tubes may then be tried, in order to minimize this error.

SECTION VI

SUPPLEMENTARY DATA

This section will enlarge on the simplified instructions given in Section III. The reader should refer to Section IV, "Theory of Operation," for detailed explanations of the circuits dealt with in this section.

1. CARRIER OSCILLATOR

a. Oscillator Filament Adjustment

(1) The average carrier oscillator tube used in the Model 84 requires a filament current of about 4.1 amperes. This current has a critical effect on performance. When the instrument is first turned on, rather high filament current will be taken by the thoriated tungsten filament until it warms up.

NOTE: Some instruments have the proper filament current shown by a red band on the ammeter, others have an engraved plate indicating the optimum adjustment for the particular tube.

(2) If the instrument is to be turned on and off frequently, it may be advisable to reduce this initial current by adjusting the screw driver control (located to the right of the filament ammeter) until the instrument warms up thoroughly.

(3) Adjustment of the oscillator filament current also varies the carrier output level, therefore resetting of the output, as described in Section III, will be necessary. Refer to page 5, paragraph 3.a.

(4) If the filament is operated at less than four amperes the tube may not oscillate over the entire range; however, if the filament current is greater than the value marked on the panel, one or more spurious components may be generated, usually when tuning through the range of 900 to 950 megacycles.

(5) These disturbances, known as "parasitics," may take various forms when viewing the modulation component of carrier on the screen of a cathode-ray oscillograph. Usually there is a "break-up" or introduction of R. F. patterns when using sine-wave modulation. The remedy for this condition is to lower the filament current.

(6) In some applications frequency modulation due to carrier hum ripple may be noticeable. This can be eliminated by supplying the oscillator tube filament from a D. C. source, as described in the Maintenance Section, page 24, paragraph d.

b. Carrier Frequency Controls

(1) The carrier frequency range is hand-calibrated at ten megacycle intervals, as indicated by the *black calibrations* on the glass-covered scale marked "Megacycles." The entire range from 300 to 1,000 megacycles may be traversed with approximately two rotations of the Coarse Frequency knob.

(2) For vernier adjustment, the Fine Frequency knob provides a reduction of 11:1, sufficient for close tuning. Each rotation of the Fine Frequency knob corresponds to one of the *Red Calibrations* on the glass-covered scale.

(3) Still further subdivision may be obtained by means of the *100 uniform calibrations* on the Fine Frequency dial.

(4) The red calibrations are not directly related to the carrier frequency. They are intended to be used, in conjunction with the 100 calibrations on the Fine Frequency dial, for keeping precise record of any particular frequency setting. This arrangement also permits the measurement of selectivity characteristics.

(5) White celluloid "selectivity" rings, directly calibrated in megacycles deviation from some particular resonant frequency, can be supplied by the Measurements Corporation. These rings are designed to slip over the Fine Frequency dial, with calibrations arranged on an extended scale to cover several rotations of the dial. For reasons of security, blank rings can be supplied and the user may calibrate them by subdividing uniformly the calibrated intervals.

(6) Mechanical backlash in this tuning system is small, but it is nevertheless good practice to always approach a desired frequency setting from the same direction.

CAUTION: When approaching the extreme upper or lower end of the carrier frequency range, high speed rotation of the coarse frequency knob should be avoided, otherwise the tuning mechanism will receive a severe jolt when the dial stop is reached. Even though this stop is protected by special construction, it can be damaged by rough handling.

c. Carrier Output Connections—Of the four 50 ohm cables supplied with the Model 84 (see Figure 2), the one with a 49268 connector at both ends should be used whenever possible. For some older equipment the cable using a 49194 connector, in conjunction with the 49268 at the generator end, may be necessary. However, this latter cable introduces a definite reflection loss at 1,000 megacycles unless means of tuning out this mismatch are available. The output jack alone will not introduce an error within the range of 300 to 1,000 megacycles covered by this generator. If it is desired to operate the Model 84 into cables having a surge impedance other than 50 ohms, the Measurements Corporation will endeavor to supply external pads with proper plug adapters, on special order.

d. Carrier Output Adjustment

(1) An adjustable fiducial rotates concentric with the Carrier Output dial. After a desired frequency has been located (with the push-button switch at "OFF"), the Carrier Output dial should be turned up for a meter reading of 100K, then the fiducial can be set opposite the 100K mark by means of its attached handle. Lower carrier levels may then be read from the Carrier Output dial. These calibrations indicate the actual voltages across the output jack, with its proper termination of 50 ohms.

(2) Some types of heterodyne receivers may have a tendency to feed back local oscillator voltage to the output metering system of the signal generator. In this case, a marked change in the Output Meter reading will occur when the cable is disconnected from the output jack of the Model 84. However, the open circuit reading of the Carrier Output meter may be accepted as the true carrier level, since the Model 84 has sufficient internal load.

(3) The Model 84 will deliver considerably more than its rated 100,000 microvolts output over the center portion of its frequency range. Accurate metering of these higher output levels may be obtained by first adjusting the output for a meter reading of 100K, then setting the movable fiducial to some convenient submultiple, such as 10K. Since 10K will equal one-tenth of the actual output it is merely necessary to multiply the output dial calibrations by ten to obtain outputs above 100K. These readings will maintain their usual accuracy up to the point where loading of the oscillator occurs. This point will be indicated by a shift in the Per Cent Modulation Meter zero and may occur before an actual output of 300K microvolts can be obtained.

e. Output Reference Level

(1) With the proper line voltage supply, an output reference level of exactly 100,000 microvolts will be applied to the Carrier Output Meter when the Calibration Check Button below this meter is depressed. The Carrier Output Dial should, of course, be turned fully counter-clockwise to eliminate the carrier itself. The accuracy of this reference level is dependent on a stable supply of exactly 117 rms. volts. This can best be obtained by connecting the Model 84 to the External Line Voltage Regulator supplied with the instrument.

(2) If the Output Meter does not indicate 100K while the Check Button is held down, the meter sensitivity may be corrected by adjusting the screw driver control to the left of the check button. However, *a large error in this output calibration check probably indicates a damaged metering crystal.* Instructions for crystal replacement are given in the Maintenance Section, page 24, paragraph e.

NOTE: It may be necessary to disconnect the receiver under test during the above calibration procedure to eliminate any injection of local oscillations from the receiver itself. (See page 29, "Carrier Output Adjustment.")

f. Output Accuracy Considerations

(1) Curves of carrier output at 25 mc. intervals are plotted for each Model 84, using precision U.H.F. Barretter bridges. Results have shown that a two decibel error in metering of the Model 84 output can be taken as an outside limit. Even this amount of error can be reduced by operating the

carrier oscillator with reduced filament current. This practice is strongly recommended whenever output accuracy is important, as excessive filament current frequently causes parasitic components to appear at certain critical frequencies, especially between 900 and 950 megacycles. The disadvantages of lowered filament current are reduced output at certain frequencies and some increase in hum and modulation distortion.

(2) There is some possibility of a change in the condition of the carrier oscillator during the time required to reduce the carrier output from its 100K calibration point to the desired output level. (See Carrier Output Adjustment, page 29.) This type of drift should be negligible when using the External Line Voltage Regulator on a power line of *good frequency stability*. However, a check on carrier stability can easily be made by setting the Per Cent Modulation Meter to zero while the Carrier Output is still at 100K. Any subsequent change in oscillator operation will be evident (when the "OFF" push-button is depressed), since the Per Cent Modulation Meter will respond to the shift in oscillator grid current which must accompany such a change.

2. MODULATION

a. General Function. The principal function of the Modulator is to vary the plate voltage of the Carrier Oscillator Tube, V-20. Two types of oscillator plate voltage control are available:

(1) Sine-Wave Modulation, during which the oscillator plate potential varies equal amounts above and below its average value of 325 volts.

(2) Pulse Modulation, which consists of a periodic interruption of the carrier, accomplished by switching the oscillator plate voltage off and on under the control of a self-contained pulse generator.

3. SINE-WAVE MODULATION

a. Adjustment

The internal sine-wave modulator provides a choice of three frequencies: 400, 1,000 or 2,500 cycles per second, selected by their corresponding push-buttons. Before applying sine-wave modulation the button marked "Off" should be depressed and the carrier adjusted to the desired frequency and output level. The Per Cent Modulation Meter should be set to zero while the "Off" button is depressed. It is well to make periodic checks of this zero adjustment, especially after large changes in carrier frequency or oscillator filament current adjustment. Modulation is applied by clockwise rotation of the knob marked "Sync. In & Mod." until the desired level is indicated by the Per Cent Modulation Meter.

b. External Modulation

The modulation amplifier may be connected to an external sine-wave generator by means of the input jack directly below the "Sync. In & Mod." knob (as in Figure 2). Operation of the "Ext." push-button will then connect the external generator to the "Sync. In & Mod." control for adjustment of the applied signal input level. External modulating frequencies within the range of 50 to 30,000 cycles may be applied, an input level of about 3 rms. volts being sufficient for 30% modulation of the carrier.

c. Reason for 30% Modulation Limit

It will be noted that no modulation levels greater than 30% are calibrated on the Model 84. Inasmuch as this signal generator is a standard of U.H.F. carrier voltage, the characteristic non-linearity of higher modulation levels was considered undesirable. The sine-wave modulator was therefore designed on the basis of 30% maximum modulation.

4. PULSE MODULATION

a. Explanation

The indications of the carrier output meter and the Per Cent Modulation Meter have no exact significance when using pulse modulation. After the carrier frequency has been located, the desired carrier output level should be selected by depressing the "OFF" push-button to obtain an unmodulated carrier (see paragraph 1. d. for Carrier Output Adjustment). When pulse modulation is introduced by depressing the push-button marked "Pulse," the carrier does not operate during the periods between pulses, but switches from a condition of no oscillation to maximum oscillation, then back to zero again, in accordance with the particular pulse width and repetition rate employed. This does not correspond to conventional 100% modulation, since the pulse modulated car-

rier will not exceed its unmodulated, or "continuous-wave" amplitude at any time. In theory, a 30% modulated carrier would have a peak-to-peak modulation component equal to 60% of a pulse modulated carrier. A fairly close approximation of these relative values should be obtained, assuming that a detector of good linearity is available.

b. Pulse Frequency Controls

The right hand Pulse Frequency control operates as a multiplier switch to cover the following ranges of Pulse Frequency:

Multiplier Switch Position	Range of Fine Pulse Frequency Dial (c.p.s.)
X 1	60 to 1,000
X 10	600 to 10 kc.
X 100	6 kc. to 100 kc.

The calibration of the Pulse Frequency controls is approximate (±20%), but an external standard of frequency may be used to synchronize the pulse repetition rate exactly. (See Figure 2.)

c. Synchronizing the Pulse Generator

The "Sync. In & Mod." knob is a dual-purpose control. In addition to its function of controlling the depth of sine-wave modulation it may also be used during pulse modulation to inject a synchronizing voltage from an external source. The external signal is applied to the lower left hand jack through one of the coaxial cables provided (see Figure 2). With this connection, the frequency stability and accuracy of the Model 84 pulse modulator will be equal to that of the external signal generator.

A sine-wave synchronizing signal is generally satisfactory and may be connected as shown in Figure 2 for accurate determination of the pulse repetition rate. If a pulse is applied to the Synchronizing Input jack the Pulse Frequency knobs will have little or no control over the repetition rate. (On models prior to Serial #146 the "Sync. In & Mod." knob must be fully clockwise when a short pulse is employed to synchronize the Model 84 pulse modulator.)

d. Pulse Width and Delay Adjustment

(1) The purpose of the *Pulse Width* control is to adjust the time during which the carrier will oscillate. This time naturally cannot ever exceed the total period between pulses, as determined by the Pulse Frequency setting. For example, if a repetition frequency of 50,000 is selected, the interval between pulses will be 20 microseconds, therefore advancing the Width control beyond the 20 microsecond point cannot increase the actual pulse width.

(2) The *Pulse Delay* dial will create a displacement of the Carrier Pulse with respect to a fixed reference point established by the Synchronizing Output Pulse, (see par. g.). This feature is used when the time base is of a type designed for external synchronization (such as the conventional "saw-tooth" oscillator).

(3) Delay control creates a "sliding pulse" effect for convenient observation of rise time and width. The Delay Dial is sufficiently accurate to enable measurements of small time intervals in U.H.F. studies.

e. Limits of Pulse Width and Delay

(1) It will be noted that certain calibrations on the pulse dials have been filled in red. This is to serve as a constant reminder that at the higher repetition frequencies it is not possible to use long pulse widths or delay. However, these red calibrations need be strictly observed only when the repetition frequency approaches 100,000. For other frequencies included in the X-100 range the graph of Figure 13 may be used to determine the maximum limits of width and delay. Attempts to delay the pulse beyond the limits given in Figure 13 may cause unpredictable changes in repetition rate.

f. Effect of Carrier Frequency on Pulse Width and Delay

(1) The Delay and Width dials are individually calibrated at a carrier frequency of 800 megacycles. However, as the carrier frequency is lowered from this point it will be found that the positive slope of the pulse will tend to become delayed with respect to the synchronizing, or "zero reference" pulse by approximately the amount shown in Figure 14. This variation is quite uniform, corresponding to the straight line function shown in Figure 14 between 300 and 750 megacycles.

(2) Figure 15 illustrates the effect of carrier oscillator inertia on the pulse width. Fig. 16 shows the worst condition (at 300 mc.) where the

pulse width control may have to be set at 7 microseconds to insure stable operation. Over most of the carrier range the pulse can be maintained at a constant minimum width of one microsecond by leaving the delay dial at zero and making small corrections of the width dial.

(3) It should be borne in mind that the above curves are for average oscillator tubes — replacement tubes may vary in their pulse performance.

g. The Synchronizing Pulse Output

(1) A fixed reference pulse of either positive or negative polarity is available from the jack below the "Sync. Out" knob. This pulse was primarily intended for use with conventional cathode-ray oscillographs provided with connections for external synchronization of the time base oscillator. (As set up in Figure 2.)

(2) If the synchronizing pulse is connected to an oscillograph not specifically designed for pulse work, some interference may occur due to cross-coupling effects. Close adjustment of the time base frequency, and selection of the most effective pulse polarity will tend to minimize this type of interference. It is often possible to make indirect connection to the oscillograph, such as a turn of insulated wire around the external synchronizing binding post. In any case, the pulse amplitude should be maintained at a point just sufficient for satisfactory locking of the time base. In severe cases of coupling, rearrangement of the oscillograph wiring and terminals may be desirable.

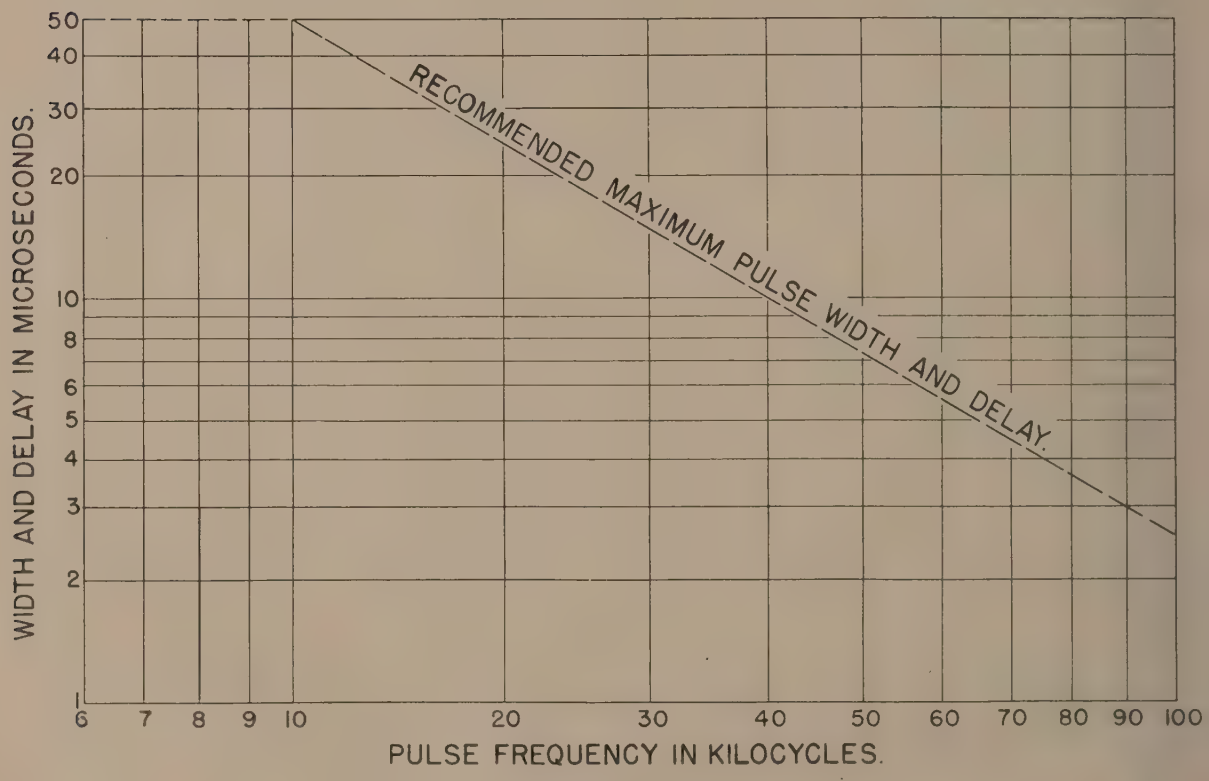


FIGURE 13

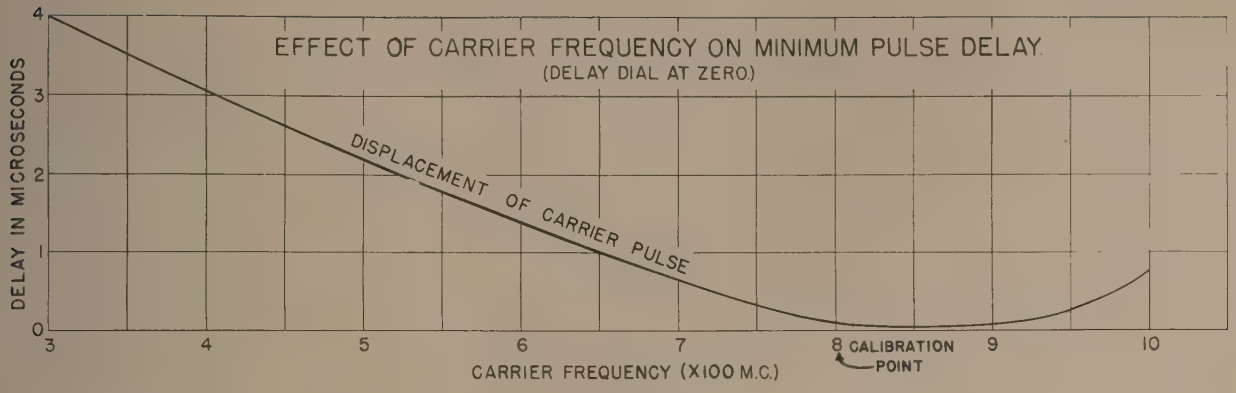


FIGURE 14

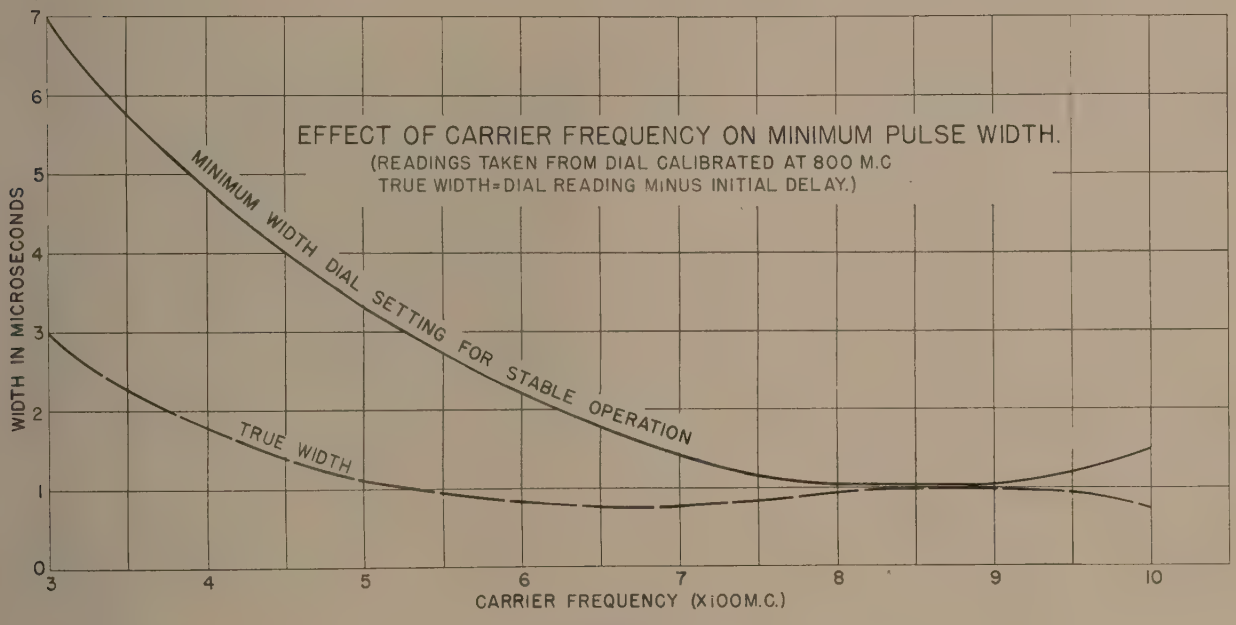


FIGURE 15

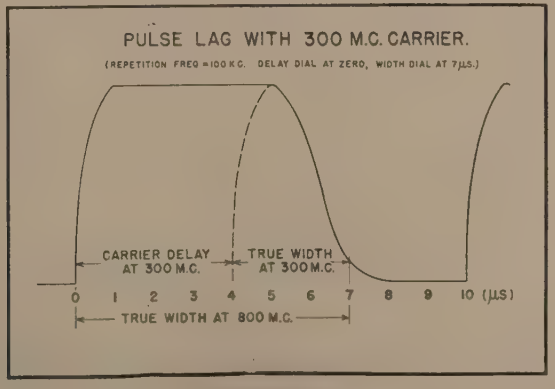

PULSE LAG WITH 300 M.C. CARRIER.
(REPETITION FREQ =100 K.C. DELAY DIAL AT ZERO, WIDTH DIAL AT 7μS.)
CARRIER DELAY AT 300 M.C.
TRUE WIDTH AT 300 M.C.
0 1 2 3 4 5 6 7 8 9 10 (μS)
TRUE WIDTH AT 800 M.C.

FIGURE 16

Additional Information with regard to the applications and maintenance of this equipment will be available from time to time. Users of the Model 84 Signal Generator are urged to discuss their problems with us and to suggest such modifications as might make the Model 84 more adaptable to their special requirements.

Maintenance difficulties should be reported before proceeding with actual repairs, since our familiarity with such problems will usually suggest a simpler procedure.

Engineering Department

MEASUREMENTS CORP.

Boonton, New Jersey

U.S.A.

SECTION VII
TABLE OF REPLACEABLE PARTS

MODEL: 84 SIGNAL GENERATOR

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
T-1	TRANSFORMER: Power; potted; core: 1⅝" tongue, #26 ga. silicon steel, window—1 5/16" x 2 5/16". Primary: 117v., 1.5 amp., 267 turns of #19 enameled copper wire, paper insul., leads Black-Black. High Voltage Secondary: 854v., .165 amp., 2050 turns of #28 enameled wire tapped at 425, 1025 and 1625 volts, leads Red-Green-White-Green-Red. 6.3v. Secondary: 6.3v., 8.0 amp., 15 turns of #14 enameled copper wire (2 in parallel), leads spaghetti covered. 5v. Secondary: 2.0 amp., 12 turns of #17 enameled copper wire, paper insul., leads Brown-Brown. 5v. Secondary: 2 amp., 12 turns of #17 enameled copper wire, paper insul., leads Yellow-Yellow. 5v. Secondary: 2.0 amp., 12 turns of #17 enamel copper wire, paper insul., leads Blue-Blue. 2v. Secondary: 5.0 amp., 5 turns of #13 enameled copper wire, paper insul., leads Black-Black. Overall rating: 160 volt-amperes.	Supplies one 6.3 volt circuit, three 5 volt circuits, one 2 volt circuit, one high voltage supply for rectifiers V-16, V-17 and V-18.	Red Arrow spec. #246 Drg. #84-L1
L-1	CHOKE: 20 henry, 110 ma. DC, 200 ohms DC resistance; core: #26 ga. silicon steel, ¾" leg, 1½" build, .01" gap, coil on each leg, each coil having 2480 turns of #26E enameled copper wire on a ¾" x 1⅞" x 2½" form.	Inductive load for anode of V-4 (Sine-Wave Modulation output tube).	Red Arrow Spec. #247 Drg. #84-L2
L-2, L-3, L-4, L-5	CHOKES: 4 in one case, 2 having 10 henrys at .17 amps., max. resistance 160 ohms DC, core: ¾" #26 ga. silicon steel with winding on one leg, .01" air gap in steel. Winding: 4500 turns of #27 enameled wire on ¾" x 1½" x 2 3/16" long form. 2 chokes having 10 henrys at .065 amps., max. resistance 450 ohms DC, core: 1" tongue standard lamination with .01" air gap in steel, coil: 4000 turns of #33 ga. enameled copper wire on 1" x 1¼" x 1 7/16" form.	Power Filter Chokes	Red Arrow Spec. #248 Drg. #84-L4
L6 & L9	R.F. CHOKE: 7 turns of #30 enamaled copper wire formed on 3/16" mandrel with 1/32" space between turns. Length of choke—5/16", length of leads—⅜".	R. F. Choke.	Meas. Drg. #84-C3-A
L7 & L10	R.F. CHOKE: flat type, seven sections of #30 enameled copper wire, .113" per section, choke length—1¼", lead length—3/16".	R. F. Choke.	Meas. Drg. #84-C2-A
L8 & L11	R.F. CHOKE: standard 100 ohm non-insulated carbon resistor, —10%, ½ watt.	R. F. Choke.	Speer SN½
L12 & L14	R.F. CHOKE: 24 turns of #18 B.S. enameled copper wire formed on ¼" mandrel and stretched to 1½" length with 1 1/16" leads.	R. F. Choke.	Meas. Drg. #84-C1-A
L13	R.F. CHOKE: 12 turns of #18 B & S enameled copper wire formed on ¼" mandrel and stretched to 1⅛" length with ½" leads.	R. F. Choke.	Meas. Drg. #84-C4-B

TABLE OF REPLACEABLE PARTS *(Continued)*

MODEL: 84 SIGNAL GENERATOR

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
L15	CHOKE: 375 mircrohenries, 200 turns of #36 B & S vitreous coated copper wire on form 1¼" long and 7/16" outside diameter of wax impregnated paper tubing with two #241 Zierick terminal lugs.	Inductive anode compensation for V-13.	Meas. Drg. #243-A
Cable A	PATCH CABLE: 48" long coaxial cable, I. T. & T. type RG-8/U with Navy type #49268 connectors at both ends.	Carrier Output.	Meas. Drg. #84-Z2C-3
Cable B	PATCH CABLE: 48" long coaxial cable, I. T. & T. type RG-8/U with Navy Type #49268 and #49195 connectors at either end.	Carrier Output.	Meas. Drg. #84-Z2C-2
Cable C	PATCH CABLE: 48" long coaxial cable, I. T. & T. type RG-8/U with Navy type #49195 connectors at both ends.	Sync. Pulse or External Modulation input.	Meas. Drg. #84-Z2C-1
Cable D	PATCH CABLE: same as cable C	Sync. Pulse or External Modulation input.	Meas. Drg. #84-Z2C-1
C1	CAPACITOR: fixed; paper dialectric impregnated with mineral oil; 100,000 uuf. ±20%; 600 volt D.C. working.	Couples V-8 anode to grid of V-4.	Solar XTIM
C2	CAPACITOR: fixed; paper dialectric impregnated with mineral oil; 10,000 uuf. ±20%; 600 volt D.C. working.	Couples signal selected by the push-button switch to the grid of V-8.	Solar XTIM
C2B	CAPACITOR: fixed; mica; 25 uuf. ±10%; 600 volt D.C. working; molded in insulating and moisture resistant material.	Permits short pulses to by-pass the "Sync. In and Mod." control, R4.	Solar MO Type
C3	CAPACITOR: fixed; mica; 200 uuf., ±10%; 600 volt D.C. working; molded in insulating and moisture resistant material.	Couples synchronizing signals from V-8 to the Multi-Vibrator, V-9.	Solar MO
C4	CAPACITOR: fixed; mica; 10,000 uuf., +5%; 600 volt D.C. working; molded in insulating and moisture resistant material.	Couples the output anode of V-9 to the input grid when multiplier switch is at X1.	Solar MW
C5	CAPACITOR: fixed; mica; 1,000 uuf., ±2%; 600 volt working; molded in insulating and moisture resistant material.	Same as C4 when multiplier switch is at X10.	Solar MW
C6	CAPACITOR: fixed; mica; 90 uuf., ±2%; 500 volt D.C. working; molded in insulating and moisture resistant material.	Same as C4 when multiplier switch is at X100.	Solar MOS
C7	CAPACITOR: same as C4.	Couples the input anode of V-9 to the output grid when multiplier switch is at X1.	Solar MW
C8	CAPACITOR: same as C5.	Same as C7 when multiplier switch is at X10.	Solar MW
C9	CAPACITOR: 90 mmfd., silver mica, ±2%	Same as C7 when multiplier switch is at X100.	Solar, C.D. or Aerovox
C10	CAPACITOR: 50 mmfd., mica, 600 volt D.C. working, ±10%	Couples output of V-9 to input grid of V-10.	Solar MO, Micamold O, C.D. or Aerovox
C11	CAPACITOR: .1 mfd., paper, 600 V.D.C. ±20%	By-pass for V-9 and V-10 "B" supply.	Solar XTIM
C12	CAPACITOR: 25 mmfd., mica, 600 V., ±10%	Couples input section anode to output section grid of V-10.	Solar MO, Micamold O, C.D. or Aerovox

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
C13	CAPACITOR: 25 mmfd., mica, 600 V., ±10%	Couples V-10 output to V-7 input grid.	Solar MO, Micamold O, C.D. or Aerovox
C14	CAPACITOR: 100 mmfd., mica, 600 V., ±10%	Couples output of second section of V-7 to input grid.	Solar MO, Micamold O, C.D. or Aerovox
C15	CAPACITOR: .001 mfd., mica.	By-pass for cathode of V-7.	Solar MO, Micamold O, C.D. or Aerovox
C16	CAPACITOR: 25 mmfd., mica, 600 V., ±10%	Couples second section anode to first section grid of V-7.	Solar MO, Micamold O, C.D. or Aerovox
C17	CAPACITOR: 50 mfd., mica, 600v., ±10%	Couples output of V-7 to grid of V-11.	Solar MO, Micamold O, C.D. or Aerovox
C18	CAPACITOR: .001 mfd., mica.	By-pass for V-11 screen.	Solar MO, Micamold O, C.D. or Aerovox
C19	CAPACITOR: .001 mfd., mica.	Couples V-11 output to V-15 grid.	Solar MO, Micamold O, C.D. or Aerovox
C20	CAPACITOR: .1 mfd., paper, 600 V.D.C. ±20%	By-pass for "B+300" to ground.	Solar XTIM
C21	CAPACITOR: .01 mfd., paper, 600 V.D.C. ±20%	Couples output of V-15 to Sync. pulse output potentiometer.	Solar XTIM
C22	CAPACITOR: .01 mfd., paper, 600 V.D.C. ±20%	Same as C21.	Solar XTIM
C23	CAPACITOR: 2mfd., paper, 400 V.D.C. ±20%	By-pass for "B+170" volt line.	Solar XDMR4-2
C24	CAPACITOR: .001 mfd., silver mica, ±1%	Capacitor in frequency determining network of the sine-wave oscillator.	Solar, C.D. or Aerovox
C25	CAPACITOR: 980 mmfd., silver mica, ±1%	Same as C24.	Solar, C.D. or Aerovox
C26	CAPACITOR: .25 mfd., paper, 600 V.D.C. ±20%	By-pass for screen of V-5.	Solar XTIM
C27	CAPACITOR: 4 mfd., paper, 300 V.D.C. +20%, —10%	Coupling anode of V-1 to cathode of V-5.	Fast-78-K1-E
C28	CAPACITOR: .01 mfd., paper, 600 V.D.C. ±20%	Coupling anode of V-5 to grid of V-1.	Solar XTIM
C29	CAPACITOR: 50 mmfd., mica, 600 V., ±10%	Coupling output of V-10 to input grid of V-14.	Solar MO, Micamold O, C.D. or Aerovox
C30	CAPACITOR: 100 mmfd., mica, 600 V., ±10%	Couples second section anode to first section grid of V-14.	Solar MO, Micamold O, C.D. or Aerovox
C31	CAPACITOR: 500 mmfd., mica, 600 V., ±10%	By-pass for cathode V-14.	Solar MO, Micamold O, C.D. or Aerovox
C32	CAPACITOR: .5 mfd., paper, 600 V.D.C., ±20%	By-pass for "B+300" supply of V-14.	Solar XDMR6-5
C33	CAPACITOR: 25 mmfd., mica, 600 V., ±10%	Couples second section grid to first section anode of V-14.	Solar MO, Micamold O, C.D. or Aerovox

TABLE OF REPLACEABLE PARTS *(Continued)*

MODEL: 84 SIGNAL GENERATOR

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
C34	CAPACITOR: 50 mmfd., mica, 600 V., ±10%	Couples output of V-14 to grid of V-13.	Solar MO, Micamold O, C.D. or Aerovox
C35	CAPACITOR: .5 mfd., paper, 600 V.D.C., ±20%	By-pass for cathode of V-13.	Solar XDMR6-5
C36	CAPACITOR: 1 mfd., paper, 400 V.D.C., ±20%	By-pass for screen of V-13.	Solar XDMRW4-1
C37	CAPACITOR: .25 mfd., paper, 600 V.D.C., ±20%	By-pass for grid resistor of V-20.	Solar XTIM
C38	CAPACITOR: 1 mfd., paper, 400 V.D.C., ±20%	Passes modulation component to V-2 anodes.	Solar XDMRW4-1
C39	CAPACITOR: approx. 50 mmfd.	U.H.F. by-pass for V-20 anode supply.	Meas. Corp. Dwg. #84-Q156
C40	CAPACITOR: approx. 50 mmfd.	Same as C39.	Meas. Corp. Dwg. #84-Q156
C41	CAPACITOR: approx. 50 mmfd.	Same as C40.	Meas. Corp. Dwg. #84-Q156
C42	CAPACITOR: approx. 115 mmfd.	Couples V-20 anode to carrier oscillator tank circuit.	Part of Meas. Dwg. #84-RH2 assembly
C43	CAPACITOR: approx. 115 mmfd.	Couples V-20 grid to carrier oscillator tank circuit.	Part of Meas. Dwg. #84-RH2 assembly
C44	CAPACITOR: approx. 100 mmfd.	U.H.F. by-pass for V-20 D.C. grid return.	Meas. Corp. Dwg. #84-Q-155
C45	CAPACITOR: approx. 100 mmfd.	Same as C44.	Meas. Corp. Dwg. #84-Q-155
C46	CAPACITOR: approx. 100 mmfd.	Same as C44.	Meas. Corp. Dwg. #84-Q-155
C47	CAPACITOR: 25 mfd., 25 volt electrolytic	Couples 60 cycle reference level voltage to the output calibration control R67.	Solar Minicap
C48	CAPACITOR: approx. 150 mmfd.	U.H.F. by-pass in output metering circuit.	Part of Meas. Dwg. #84-OH2
C49	CAPACITOR: approx. 125 mmfd.	U.H.F. by-pass for V-20 filter.	Part of Meas. Dwg. #84-RH2
C50	CAPACITOR: approx. 1500 mmfd.	Same as C49.	Same as C49
C51	CAPACITOR: approx. 1500 mmfd.	Same as C49.	Same as C49
C52	CAPACITOR: approx. 1500 mmfd.	Same as C49.	Same as C49
C53 to C58 incl	CAPACITORS: 8 mfd., paper.	Power supply filter capacitors.	Meas. Corp. Dwg. #84-K1
R1	RESISTOR: 350 ohm, ±10%; 2 watt.	Cathode bias resistor for V-4.	Speer SI-2

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
R2	RESISTOR: 500,000 ohms, ±10%; ½ watt.	Grid resistance for V-4.	Speer SI-½
R3	RESISTOR: 150,000 ohms, ±10%; ½ watt.	Feedback resistor from anode of V-4 to cathode of V-8.	Speer SI-½
R4	POTENTIOMETER: 500,000 ohms, carbon; "Audio Grid" taper; 7/16 inch shaft length.	Sync. input and modulation gain control.	Centralab #79-TI
R5	RESISTOR: 2,000 ohms, ±10%; ½ watt.	Cathode bias resistor for V-8.	Speer SI-½
R6	RESISTOR: 4,000 ohms, ±10%; 20 watt; wirebound, cement or vitreous coated.	To prevent current overload of gaseous regulator tube V-6.	Clarostat
R7	RESISTOR: 30,000 ohms, ±10%; ½ watt.	Anode resistor for V-8.	Speer SI-½
R8	RESISTOR: 12,000 ohms, ±5%; 2 watt.	Anode resistor for input section of V-9.	Centralab Type 316
R9	RESISTOR: same as R8.	Anode resistor for output section of V-9.	Centralab Type 316
R10	RESISTOR: 15,000 ohms, ±5%; ½ watt.	Fixed grid resistor for input section of V-9.	Speer SI-½
R11	RESISTOR: same as R10.	Fixed grid resistor for output section of V-9.	Speer SI-½
R12	DUAL POTENTIOMETER: 500,000 ohms, ±10%; 2 watt; carbon composition on bakelite strip; special taper.	Variable resistors for input and output sections of V-9.	Centralab #4010081
R13	RESISTOR: 12,000 ohms, ±5%; 2 watt; carbon.	Anode resistor for input section of V-10.	Centralab Type 316
R14	RESISTOR: same as R13.	Anode resistor for output section of V-10.	Centralab Type 316
R15	RESISTOR: 5,000 ohms, ½ watt, ±10%	Grid to cathode return for first section of V-10.	Speer SI-½
R16	RESISTOR: same as R15.	Cathode resistor for V-10.	Speer SI-½
R17	RESISTOR: 30,000 ohms, ½ watt, ±10%	Grid to ground return for second section of V-10.	Speer SI-½
R18	RESISTOR: 200,000 ohms, ½ watt, ±10%	Bias resistor for second section of V-10.	Speer SI-½
R19	RESISTOR: 12,000 ohms, 2 watt, ±5%	Anode resistor for first section of V-7.	Centralab Type 316
R20	RESISTOR: same as R19.	Anode resistor for second section of V-7.	Centralab Type 316
R21	RESISTOR: 5,000 ohms, ½ watt, ±10%	Part of grid to cathode return for input of V-7.	Speer SI-½
R22	VARIABLE RESISTOR: 20,000 ohms, wirewound, linear taper, screw driver adjust, ⅛" shaft length.	To adjust arrival time of sync. pulse output.	Clarostat P-58
R23	RESISTOR: 30,000 ohms, ½ watt, ±10%	Grid to ground return for second section of V-7.	Speer SI-½
R24	RESISTOR: 200,000 ohms, ½ watt, ±10%	Bias resistor for second section of V-7.	Speer SI-½

TABLE OF REPLACEABLE PARTS *(Continued)*

MODEL: 84 SIGNAL GENERATOR

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
R25	RESISTOR: 10,000 ohms, 20 watt, wirewound, cement or vitreous coated.	Anode resistor for V-11.	Clarostat, Wirt or IRC
R26	RESISTOR: 1,000 ohms, ½ watt, ±10%	Grid return for V-11.	Speer SI-½
R27	RESISTOR: 15,000 ohms, 20 watt, ±10%, wirewound, cement or vitreous coated.	Screen grid resistor for V-11.	Clarostat, Wirt or IRC
R28	RESISTOR: 10,000 ohms, ½ watt, ±10%	Anode resistor for V-15.	Speer SI-½
R29	RESISTOR: 500,000 ohms, ½ watt, ±10%	Grid return for V-15.	Speer SI-½
R30	RESISTOR: 5,000 ohms, ½ watt, ±10%	Cathode resistor for V-15.	Speer SI-½
R31	POTENTIOMETER: 20,000 ohms, wirewound linear taper, screw driver adjust, ⅛" shaft length.	To control amplitude and polarity of sync. pulse output.	Clarostat P-58
R32	RESISTOR: 30,000 ohms, 1 watt, ±10%	To lower the anode supply for V-8 and V-5.	Centralab Type 314 or Speer SI-1
R33	RESISTOR: 265,000 ohms, 1 watt, ±2%	To shunt R38 for 1000 cycle sine-wave modulation.	Continental Type X1
R34	RESISTOR: Same as R33.	To shunt R37 for 1000 cycle sine-wave modulation.	Continental Type X1
R35	RESISTOR: 76,400 ohms, 1 watt, ±2%	To shunt R38 for 2500 cycle sine-wave modulation.	Continental Type X1
R36	RESISTOR: Same as R35.	To shunt R37 for 2500 cycle sine-wave modulation.	Continental Type X1
R37	RESISTOR: 400,000 ohms, 1 watt, ±2%	To tune sine-wave oscillator for 400 cycle modulation.	Continental Type X1
R38	RESISTOR: 400,000 ohms, 1 watt, ±2%	To tune sine-wave oscillator for 400 cycle modulation.	Continental Type X1
R39	RESISTOR: 100,000 ohms, ½ watt, ±10%	Anode resistor for V-5.	Speer SI-½
R40	RESISTOR: 500,000 ohms, ½ watt, ±10%	Screen resistor for V-5.	Speer SI-½
R41	VARIABLE RESISTOR: 10,000 ohms, wirewound, linear taper, screw driver adj. ⅛" shaft length.	To control inverse feed-back from V-1 to V-5.	Clarostat #P-58 or IRC#W
R42	RESISTOR: 10,000 ohms, 20 watt, ±10%, wirewound, cement or Vitreous coated.	Anode resistor for V-1.	Clarostat, Wirt, or IRC
R43	RESISTOR: 500,000 ohms, ½ watt, ±10%	Grid return for V-1.	Speer SI-½
R44	RESISTOR: 700 ohm, ½ watt, ±10%	Cathode resistor for V-1.	Speer SI-½
R45	RESISTOR: 12,000 ohms, 2 watt, ±5%	Anode resistor for first section of V-14.	Centralab Type 316 or Speer SI-2
R46	RESISTOR: 12,000 ohms, 2 watt, ±5%	Anode resistor for second section of V-14.	Centralab Type 316 or Speer SI-2

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
R47	RESISTOR: 10,000 ohms, ½ watt, ±10%	Fixed portion of V-14 grid return.	Speer SI-½
R48	POTENTIOMETER: 500,000 ohms, carbon special taper, bakelite resistor strip, reduce shaft length to 7/16".	Variable portion of V-14 grid return controlling arrival time of modulation pulse output.	Centralab
R49	RESISTOR: 5,000 ohms, 2 watt, ±5%	Cathode resistor for V-14.	Centralab Type 316 or Speer SI-2
R50	RESISTOR: 30,000 ohms, ½ watt, ±10%	Grid to ground return for second section of V-14.	Speer SI-½
R51	RESISTOR: 200,000 ohms, ½ watt, ±10%	Grid bias resistor for second section of V-14.	Speer SI-½
R52	RESISTOR: 34 ohms, ½ watt, ±10%	Protective series grid resistor for V-13.	Speer SI-½
R53	RESISTOR: 400 ohms, ½ watt, ±10%	Fixed portion of V-13 grid return.	Speer SI-½
R54	POTENTIOMETER: 500,000 ohms, carbon, special taper, bakelite resistor strip, reduce shaft length to 7/16".	Variable portion of V-13 grid return controlling duration of modulation pulse output.	Centralab 79-T1
R55	RESISTOR: 1,000 ohms, 2 watt, ±10%	Screen resistor for V-13.	Centralab Type 316 or Speer SI-2
R56	RESISTOR: 2,000 ohms, 2 watt, ±10%	Anode resistor for V-13.	Centralab Type 316 or Speer SI-2
R57	RESISTOR: 1,000 ohms, 2 watt, ±10%	D.C. grid return for V-20.	Centralab Type 316 or Speer SI-2
R58	POTENTIOMETER: 5,000 ohms, carbon linear taper, bakelite resistor strip, shaft length 7/16".	To set electrical zero of Per Cent Modulation Meter.	Centralab Type P-58 IRC Type W
R59	RESISTOR: 76,400 ohms, 1 watt, ±2%	D.C. path for V-20 grid current to M1.	Continental Type X1
R60	RESISTOR: 15,000 ohms, 1 watt, ±2%	To limit rectified a.c. component of V-20 grid current through M1.	Continental Type X1
R61	RESISTOR: 400,000 ohms, 1 watt, ±2%	To reduce voltage across R63.	Continental Type X1
R62	RESISTOR: 265,000 ohms, 1 watt, ±2%	To reduce loading effect of R63 on modulation metering circuit.	Continental Type X1
R63	POTENTIOMETER: 20,000 ohms, wirebound, linear taper, screw driver adjust, ⅛" shaft.	For calibrating the Per Cent modulating metering circuit.	Clarostat P-58
R64	RESISTOR: 12.6 ohms.	Output arm of carrier output "T" pad.	Part of Meas. Dwg. #84-OH2
R65	RESISTOR: 68.7 ohms.	Input arm of carrier output "T" pad.	Part of Meas. Dwg. #84-OH2
R66	RESISTOR: 48.7 ohms.	Shunt arm of carrier output "T" pad.	Part of Meas. Dwg. #84-OH2

TABLE OF REPLACEABLE PARTS *(Continued)*

MODEL: 84 SIGNAL GENERATOR

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
R67	VARIABLE RESISTOR: 10,000 ohms, wirebound, linear taper, screw driver adjust, 1/8" shaft length.	To adjust carrier output meter sensitivity.	Clarostat P-58 or IRC #W
R68	POTENTIOMETER: 50 ohms, wirewound, linear taper, screw driver adjust, 3/32" shaft length.	Factory adjustment of 60 cycle output reference level.	Meas. Corp. Dwg. #84-T4
R69	VARIABLE RESISTOR: .5 ohm, 50 watt, screw driver adjust shaft.	To adjust filament current of V-20.	Ohmite
R70	RESISTOR: 2,500 ohms, 20 watt, ±10%, vitreous or cement coated.	"B" supply filter element.	Wirt
R71	RESISTOR: 200,000 ohms, 1/2 watt, ±10%	"B" supply bleeder.	Speer SI-1/2
R72	RESISTOR: 3,000 ohms, 20 watt, ±10%, vitreous or cement coated.	Filter element in V-12 screen supply.	Wirt
R73	RESISTOR: 15,000 ohms, 20 watt, ±10%, vitreous or cement coated.	Bleeder between "B+" and V-12 screen supply.	Wirt
	OUTER CASE: 26 1/8" x 12 1/8" x 10"; .050" crs. or auto body steel, copper and dull white nickel plate finish, fine black wrinkle paint outside.	Cover for entire assembly.	Meas. Corp. Drg. #84-A56
	DIAL COVER: 10 9/16" x 10 1/2" x 3/4"; .064" 2S-1/2 hard aluminum; finish: potash dip, fine black wrinkle paint, engraved per Drg. #84-F2.	Cover for tuning mechanism.	Meas. Corp. Drg. #84-A51
	A.C. AMMETER: 0-5 amperes a.c. Weston Type #517, 25-500 cycles approx. resistance .01 ohm, accuracy 2%	Indicating filament current of carrier oscillator tube, V-20.	Meas. Corp. Drg. #84-A64
	OUTPUT DIAL: 2 3/4" dia., .064" nickel silver, finish frosted chrome, engraved or stamped, letters black compound filled.	Adjusting carrier output.	Meas. Corp. Drg. #Q-113-C
	OUTPUT DIAL FIDUCIAL: black bakelite on 3 9/32" x 5/8" arm of .050" 1/2 hard brass; handle of 3/16" dia. brass.	Adjustable reference mark for carrier output dial.	Meas. Corp. Drg. #84-AH18
	TUNING DIAL: 2 3/4" dia., .064" nickel silver; finish frosted chrome, engraved or stamped with black compound filled letters.	Adjustment of small carrier increments.	Meas. Corp. Drg. #Q-114-C
	WHITE CALIBRATION DIAL: 4 1/2" dia., 1/16" brass, bright dip and painted with special white dial lacquer. Individually calibrated and printed.	Main carrier frequency dial.	Meas. Corp. Drg. #84-A42-D
	FREQUENCY FIDUCIAL ASSEMBLY: Weston 2" meter case modified with fiducial #84-F5 and fiducial mask #84-F6.	Hairline indicator for main frequency dial.	Meas. Corp. Drg. #84-AH17
	FINE FREQUENCY FIDUCIAL: black bakelite, to fit 2 3/4" dial, hairline filled in white.	Indicator for fine carrier frequency dial.	Meas. Corp. Drg. #Q-116
	FLANGED KNOBS: (2 supplied), modified from Kurz-Kasch S-311-64BB.	For carrier frequency and output adjustments.	Meas. Corp. Drg. #Q-45
S-4	SINGLE PUSH-BUTTON SWITCH: modification of oak type #21192 switch.	For output calibration check.	Meas. Corp. Drg. #65-V-1
	SWITCH BUTTON: standard Kurz-Kasch S-328-64.	For S-4.	Kurz-Kasch S-328-64
S-3	A.C. SWITCH (toggle): standard short shank S.P.S.T.	Power switch.	Any
S-2	ROTARY SWITCH: modified oak type 3 pole, 3 position; double eyelet, solid silver contacts.	Selects pulse frequency ranges.	Meas. Corp. Drg. #79-V-1

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
S-1	PUSH-BUTTON SWITCH: modified oak 6 button, 4 S.P.D.T. sections per button.	Selects type of modulation.	Meas. Corp. Drg. #54-V-1
F-1	FUSE: 2 ampere, type 3 AG. FUSE HOLDER: standard for type 3 AG fuse, mounting in 1/2" hole. PILOT LAMP: red jewel, bayonet type similar to #88.	Protective fuse in a.c. power line. Fuse holder for F-1. Operating indicator.	Bussman Type 3 AG Bussman Type HKM Signico Type 807-BF
	PILOT BULB: 6.3 volt bayonet base.	For pilot lamp.	G.E. #44
	PUSH-BUTTONS: Kurz-Kasch S-386-64, engraved and filled in white.	Modulation push-buttons.	Meas. Corp. Drg. #84-F3
	RECEPTACLE: Navy Type 49194 (2 supplied).	For external modulation and sync. input connections.	Selectar, Amphenol or Mendelsohn CSX-49194
	POTENTIOMETER LOCKING CAP: (3 supplied), 1/2" free turning brass rod, milled, finish bright dip.	Protects screw driver potentiometer adjustments.	Meas. Corp. Drg. #S-74-2
	POTENTIOMETER LOCKING CAP: (1 supplied), 1/2" free turning brass rod, milled, finish bright dip.	Protects adjustment of output reference level.	Meas. Corp. Drg. #S-74-1
	MODULATOR CHASSIS COVER: 8 15/16" x 9.015" x 6 1/2", shaped and punched from .032" auto body steel, copper and nickel-plated acid dip finish.	Shield for modulator assembly.	Meas. Corp. Drg. #84-M2
	LUG STRIP ASSEMBLY: 16 Zierick #218 lugs on 5 1/2" x 3 1/4" LE grade 1/16" bakelite strip, mounted on 2 1/4" x 1/16" steel brackets.	Supports V-19 and various electrical components.	Meas. Corp. Drg. #84-MH4
	KNOBS: (3 supplied), Kurz-Kasch S-308-64, engraved by Meas.	"Sync. In and Mod.", "Sync. Out" and "Mod. Zero".	Meas. Corp. Drg. #84-F3
	KNOBS: (4 supplied), Kurz-Kasch S-385-64, engraved by Meas.	"Pulse Delay", "Pulse Width" and "Pulse Freq.".	Meas. Corp. Drg. #84-F3
	DIALS: (4 supplied), 2" dia., 1/16" thick nickel silver, frosted chrome finish with 1/2" dia. hole; individually engraved by Meas.	Individually engraved pulse modulator dials.	Meas. Corp. Drg. #84-F4
	FIDUCIALS: (4 supplied), for 2" dials; black bakelite with hairline indentation filled in white.	Indicators for four pulse modulator dials.	Meas. Corp. Drg. #Q-121-C
M-1	MODULATION METER: 4 17/64" x 3.956" case, black bakelite, special scale, 400 ohms resistance, accuracy 5% of full scale, sensitivity 200 micro-amperes.	Indicator Per Cent modulation.	Meas. Corp. Drg. #84-A1
M-2	OUTPUT METER: 4 17/64" x 3.956" black bakelite case with 200 micro-ampere, 400 ohms movement accurate to 5% of full scale, special scale.	Indicates carrier output.	Meas. Corp. Drg. #84-A2
	SCREWS: 6-32 French Head x 1" black nickel-plated brass (8 supplied).	Screws for Per Cent modulation and output meters.	United Screw
	SCREWS: 3-48 x 1/4" FHBMS black N.P. (2 supplied).	General.	United Screw
	SUPPORTING BLOCK: white pine, brown stain finish (2 supplied).	Supports for entire assembly.	Meas. Corp. Drg. #84-Z1
	WOOD SCREWS: #8 RHSWS 1/2", black nickel-plated brass (4 supplied).	Screws for supporting blocks.	United Screw
	A.C. LINE CORD: G.E. type S153188 6' long 2/18 ST special cord with #2800 plug molded on one end, other end stripped 1 1/8" with 5/8" bare copper twist.	Connects to voltage regulator or power line.	G.E. type S153188

TABLE OF REPLACEABLE PARTS *(Continued)*

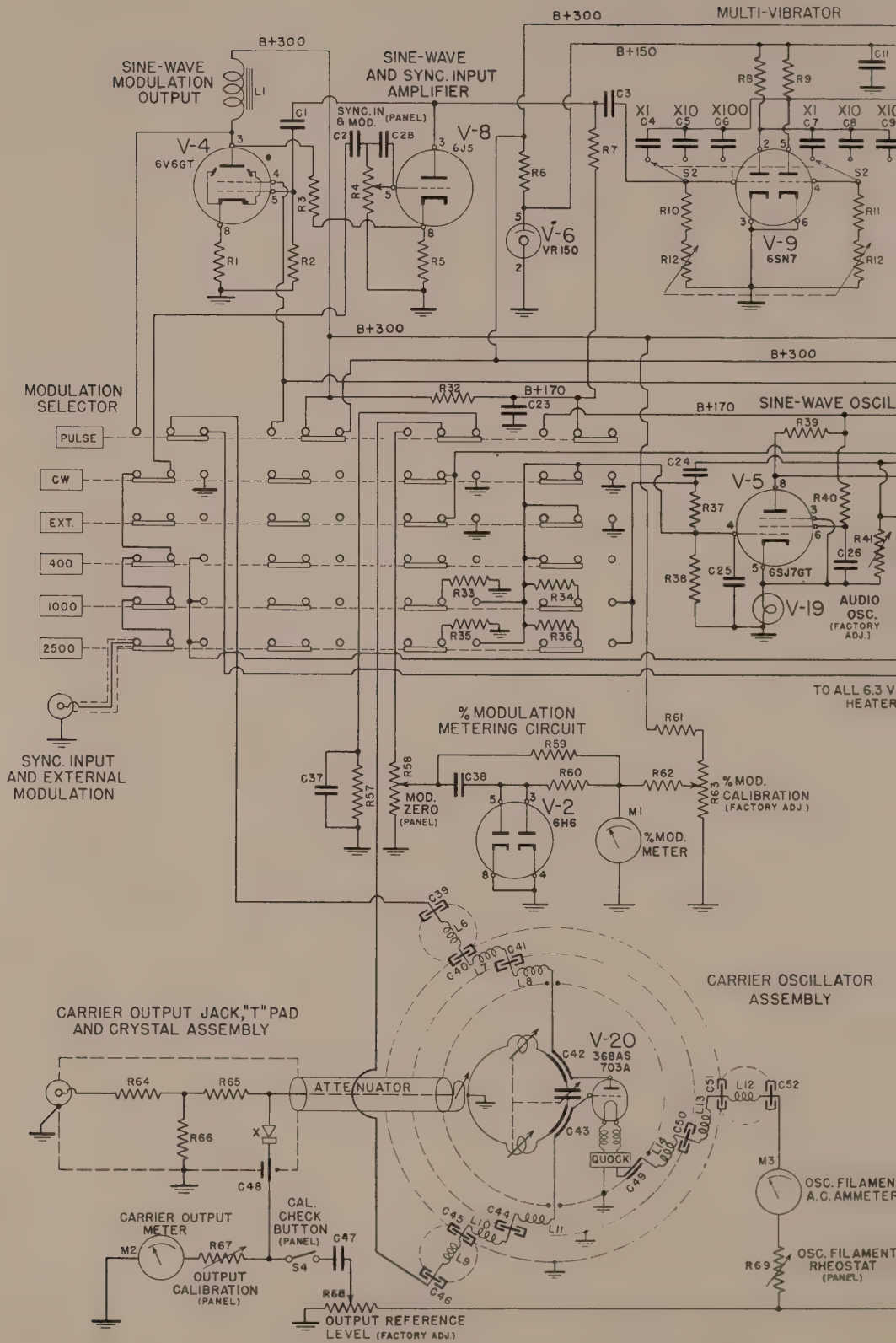
MODEL: 84 SIGNAL GENERATOR

Reference Symbol	Name of Part and Description	Function	Mfg. and Designation
	RUBBER GROMMET: ½" dia.	Protects a.c. line cord.	American Radio Hardware #1121
	LINE VOLTAGE REGULATOR: standard Sola type 3003 with 5' line cord and molded plug. 5" x 5" x 11", weight 25¾ lbs., one receptacle.	Maintains constant a.c. supply.	Sola Type #3003
	SET SCREW: cup point, hollow head.	Secures output crystal.	Bristow #6
	STOP ARM ASSEMBLY:	Limits rotation of carrier frequency mechanism.	Meas. Corp. Drg. #84-AH61
	COARSE FREQUENCY TUNING SHAFT GEAR ASSEMBLY:	Part of carrier frequency tuning mechanism.	Meas. Corp. Drg. #84-AH59
	COARSE TUNING SPLIT GEAR AND HUB ASSEMBLY:	Part of carrier frequency tuning mechanism.	Meas. Corp. Drg. #84-AH43
	CALIBRATION DIAL BEARING HUB:	Bearing for calibrated carrier frequency dial.	Meas. Corp. Drg. #84-A45
	CALIBRATION DIAL GEAR:	Rotates main carrier frequency dial.	Meas. Corp. Drg. #84-A44
	CALIBRATION DIAL RETAINER WASHER:	Retains calibrated main carrier frequency dial.	Meas. Corp. Drg. #84-A46
	FINE TUNING SHAFT PANEL BEARING:	Bearing for fine carrier frequency shaft.	Meas. Corp. Drg. #84-A34
	OSCILLATOR CHAMBER ASSEMBLY:	Carrier oscillator assembly.	Meas. Corp. Drg. #84-RH2
	ATTENUATOR AND CRYSTAL OUTPUT BLOCK ASSEMBLY:	To control and meter the carrier output.	Meas. Corp. Drg. #84-OH2
	SPACER SHIM:	For attenuator tube mounting channel.	Meas. Corp. Drg. #84-020
	ATTENUATOR DRIVE SHAFT BEARING:	Bearing for attenuator drive shaft.	Meas. Corp. Drg. #84-A13
	ATTENUATOR DRIVER GEAR:	Drives attenuator rack assembly.	Meas. Corp. Drg. #84-A63
	SET SCREW: cup point, hollow head.	General.	Bristow #142
	ATTENUATOR OUTER TUBE GROUND PLATE:	Grounding for outer attenuator tube.	Meas. Corp. Drg. #84-R33
	ATTENUATOR OUTER TUBE GROUND CLAMP:	Grounding for outer attenuator tube.	Meas. Corp. Drg. #84-R34
	COARSE TUNING SPLIT GEAR AND HUB ASSEMBLY:	Part of carrier frequency dial drive assembly.	Meas. Corp. Drg. #84-AH43
	LOCKWASHER: cadmium-plated.	General.	Shakeproof #1914
	OSCILLATOR SHIELD BASE AND COVER:	To prevent stray radiation of carrier.	Meas. Corp. Drg. #84-R32
	SHIELD CAN COVER CLIP:	To retain outer shield can.	Meas. Corp. Drg. #Q-128-2
	FILTER SHIELD CAN: (3 supplied).	To prevent stray radiation of carrier.	Meas. Corp. Drg. #80-R20
	FILTER SHIELD COVER: (3 supplied).	To prevent stray radiation of carrier.	Meas. Corp. Drg. #80-R69
	FELT PAD: 2" x 2" x ¾".	To separate outer and inner shield cans.	Boothfelt #9 felt

PARTS LIST—MODEL 84

PART	VALUE
C1	.1 mfd. paper
C2	.01 mfd. paper
C2B	50 mmfd. mica
C3	200 mmfd. mica
C4	.01 mfd. mica
C5	.001 mfd. mica
C6	90 mmfd. mica
C7	.01 mfd. mica
C8	.001 mfd. mica
C9	90 mmfd. mica
C10	50 mmfd. mica
C11	.1 mfd. paper
C12	25 mmfd. mica
C13	25 mmfd. mica
C14	100 mmfd. mica
C15	.001 mfd. mica
C16	25 mmfd. mica
C17	50 mmfd. mica
C18	.001 mfd. mica
C19	.001 mfd. mica
C20	.1 mfd. paper
C21	.01 mfd. paper
C22	.01 mfd. paper
C23	2 mfd. paper
C24	.001 mfd. mica
C25	980 mmfd. mica
C26	.25 mfd. paper
C27	4 mfd. paper
C28	.01 mfd. paper
C29	50 mmfd. mica
C30	100 mmfd. mica
C31	500 mmfd. mica
C32	.5 mfd. paper
C33	25 mmfd. mica
C34	50 mmfd. mica
C35	.5 mfd. paper
C36	.1 mfd. paper
C37	.25 mfd. paper
C38	1 mfd. paper
C39	approx. 50 mmfd.
C40	" 50 mmfd.
C41	" 50 mmfd.
C42	" 115 mmfd.
C43	" 115 mmfd.
C44	" 100 mmfd.
C45	" 100 mmfd.
C46	" 100 mmfd.
C47	25 mfd. elect.
C48	approx. 150 mmfd.
C49	" 125 mmfd.
C50	" 1750 mmfd.
C51	approx. 1750 mmfd.
C52	" 1750 mmfd.
C53 to C58	8 mfd. paper
R1	350 ohm, 2w.
R2	500K, ½w.
R3	150K, ½w.
R4	500K, pot.
R5	2K, ½w.
R6	4K, 20w.
R7	30K, ½w.
R8	12K, 2w.
R9	12K, 2w.
R10	15K, ½w.
R11	15K, ½w.
R12	500K, dual pot.
R13	12K, 2w.
R14	12K, 2w.
R15	5K, ½w.
R16	5K, ½w.
R17	30K, ½w.
R18	200K, ½w.
R19	12K, 2w.
R20	12K, 2w.
R21	5K, ½w.
R21B	20K, pot.
R22	5K, 2w.
R23	30K, ½w.
R24	200K, ½w.
R25	10K, 20w.
R26	1K, ½w.
R27	15K, 20w.
R28	10K, ½w.
R29	500K, ½w.
R30	5K, ½w.
R31	20K, pot.
R32	30K, 1w.
R33	265K, 1w.
R34	265K, 1w.
R35	76.4K, 1w.
R36	76.4K, 1w.
R37	400K, 1w.
R38	400K, 1w.
R39	100K, ½w.
R40	500K, ½w.
R41	10K, pot.
R42	10K, 20w.
R43	500K, ½w.
R44	700 ohm, ½w.
R45	12K, 2w.
R46	12K, 2w.
R47	10K, ½w.
R48	500K, pot.
R49	5K, 2w.
R50	30K, ½w.
R51	200K, ½w.
R52	34 ohm, ½w.
R53	400 ohm, ½w.
R54	500K, pot.
R55	1K, 2w.
R56	2K, 2w.
R57	1K, 2w.
R58	5K, pot.
R59	76.4K, 1w.
R60	15K, 1w.
R61	400K, 1w.
R62	265K, 1w.
R63	20K, pot.
R64	12.6 ohm
R65	68.7 ohm
R66	48.7 ohm
R67	10K, pot.
R68	50 ohm, pot.
R69	.5 ohm, pot.
R70	2.5K, 20w.
R71	200K, ½w.
R72	3K, 20w.
R73	15K, 20w.
F1	2 amp. fuse
L1	20 henry, 200 ohms (Meas. #84-L2)
L2	10 henry, 450 ohms (Meas. #84-L4)
L3	" " "
L4	" " "
L5	" " "
L6	Meas. #84-C3-A
L7	Meas. #84-C2-A
L8	100 ohm non-ins. carbon resistor
L9	Meas. #84-C3-A
L10	Meas. #84-C2-A
L11	100 ohms non-ins. carbon resistor
L12	Meas. #84-C1-A
L13	Meas. #84-C4-B
L14	Meas. #84-C1-A
L15	Meas. #243-A

FIGURE 17—WIR



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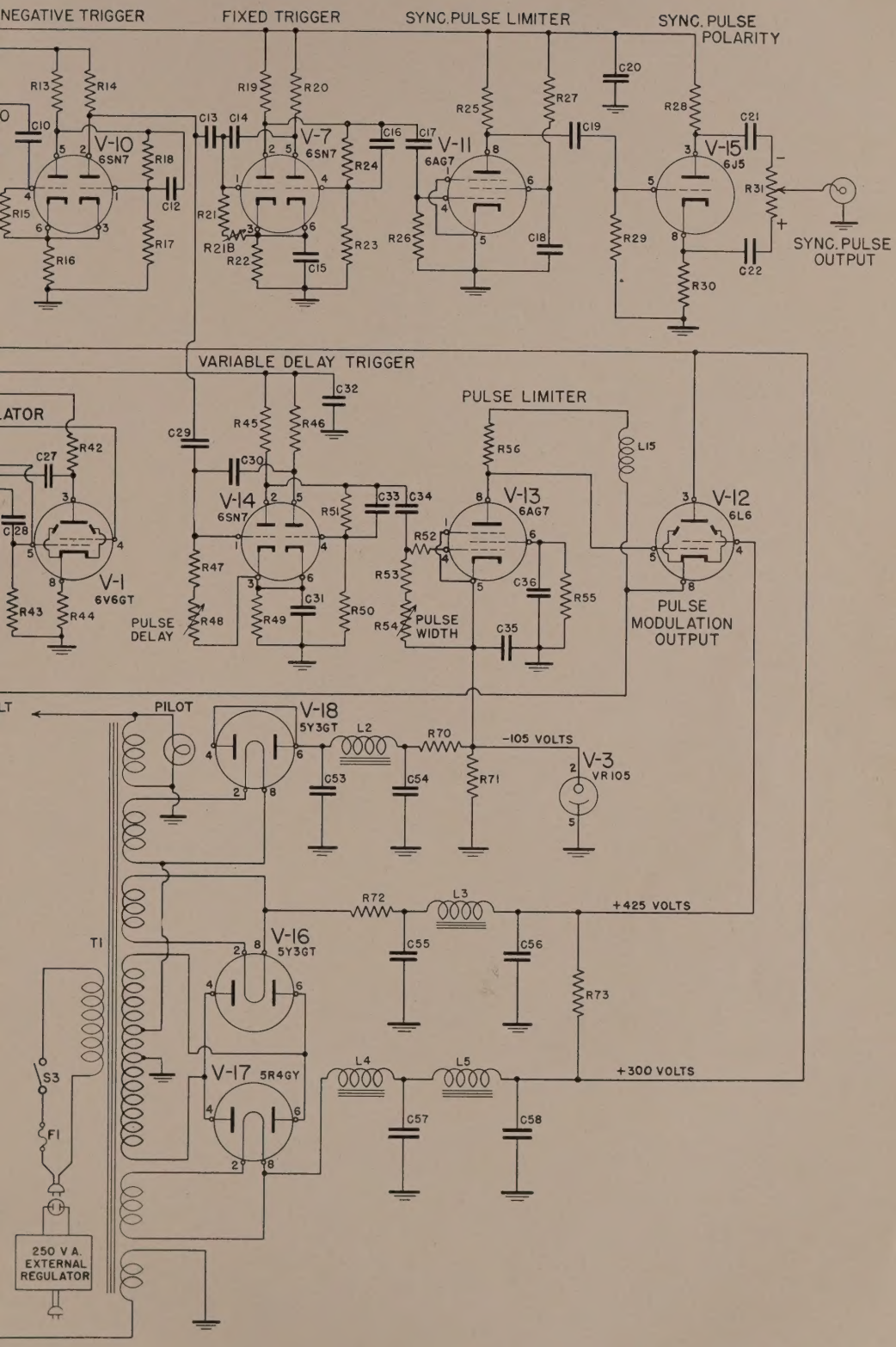

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